The
Geographical Journal.

No. 2. AUGUST, 1903. Vol. XXII.

EARTH-MOVEMENTS IN THE BAY OF NAPLES.*

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"Jacent in litore ædificiorum fragmenta quæ romanam maiestatem præseferunt, abierunt in scopulos crustatis piscium generibus habitatos."—Capaccio, 'Hist. Neap.,' cap. xiv. 1607.

In a preliminary note read at the Bradford Meeting of the British Association in 1900, it was suggested that the ancient ruins in the sea along the Neapolitan shore might yield satisfactory information regarding the Roman coast-line of the Phlegræan Fields. With this view a new survey of parts of the coast was prepared and an interim report was laid before the 1901 Meeting by the Committee on "the changes of the land-level of the Phlegræan Fields." We hope that, by describing the more noteworthy geographical results, a light may be thrown on some vexed problems and may tend to elucidate them. Babbage and others have shown that the burrows of marine shell-fish in the columns of the Temple of Serapis, at a height of about 19 feet above sea-level, bear witness to a subsidence followed by an elevation of the land through not less than this distance since the construction of the building. We have been able to collect supplementary evidence which indicates that since the Roman dominion the Neapolitan coast first sank about 35 feet, and then rose about 19 feet to slightly above its present level. Reasons will be given for believing that this great oscillatory movement was not of a seismic nature and confined to the immediate vicinity of a volcano, but affected so large an area that it must be regarded as of the order of those slow and majestic movements of the crust of the Earth which are now in progress in Sweden and elsewhere, by which continents have risen from the sea, and which can often only be detected by observations spread over a long space of time.

* Read at the Royal Geographical Society, February 9, 1903. Map, p. 236.

The assertion that the land-level in Roman times was about 16 feet higher than it is at present, depends partly upon the discovery of two submerged regions covered by the foundations of numerous houses, perhaps the forgotten site of Parthenope or Palæpolis, with an ancient harbour and a coast road, which are not without archæological interest.

To the authors whose works inspired and facilitated our labours, we would make most grateful acknowledgment. Without Lyell, Niccolini, Beloch and many another, we could have accomplished but little in the time at our disposal. We also thank our fellow-members of the British Association for their encouragement of the work, and H.B.M. Consul-General at Naples, Mr. E. Neville-Rolfe, for furthering our plans.

I. CAPRI.

Indications of changes in the level of the island of Capri are very numerous and clear, and many are of comparatively recent date.

It is not proposed to discuss here that vast series of earth-movements which have resulted in the uprising of the Capriote Tertiary limestones from a horizontal position on the sea-bottom to the surface and higher, with a dip from south to north at angles varying from 25° to 70°. Concerning the details of these very ancient changes on a gigantic scale we have but scanty knowledge; they no doubt were in operation before the strata of Capri had become dislocated from those of an extensive limestone continent. Some of the evidence we are about to consider points to the long-continued existence of the island nearly in its present form.

The most important evidence of relative levels of sea and land in former times is of three kinds. Firstly, *marks of marine erosion*, occurring either above or below the present sea-level; secondly, *raised beaches*, or beaches apparently collected by, but now beyond the reach of the waves; and, thirdly, *submerged constructions*, now standing at a lower level than that at which they were built.

Marine Erosion at the Present Day.—The details of the process of erosion of limestone by the sea may be well studied at many places around the coast of Capri. Owing to the absence of a large tide in this part of the Mediterranean, the erosive action of the waves is nearly confined to one horizontal zone. In those parts of the island where the cliffs rise sheer from deep water, and are neither too much exposed to the fierce onslaught of storm waves, nor composed of rock of too friable a nature, there we find a groove chased horizontally along the face of the cliffs at the water-line. The size and depth of this groove varies with the hardness or exposure of the rock, but on the whole it is deepest at the mean tide-level.

The most vigorous erosion, therefore, is taking place between wind and water.

Immediately above and below the water-line, erosion is proceeding very slowly; above, partly on account of the absence of the eroding medium, partly on account of a protective coat of calcium carbonate dissolved from the rocks above and spread by a trickling film of spring water. In some places there is an organic growth forming a conspicuous black band distant a foot or two from the water; this also seems to have a protective action. Beneath the surface of the water, but near enough to benefit by the foam of breaking waves, a garb of coralline and algal growth luxuriates, and protects the stone.

The size and appearance of the narrow horizontal groove indicate that it is chiefly the result of steady erosion by solution in *calm* weather

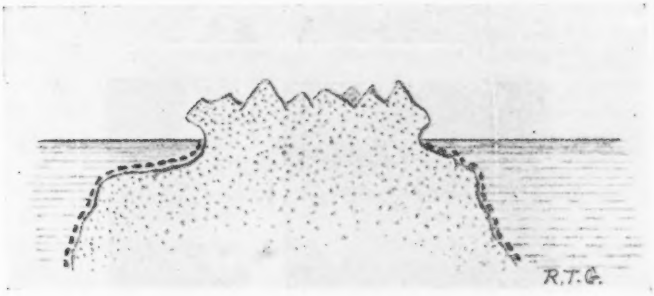

FIG. 1.—PARTIALLY ERODED BLOCK OF LIMESTONE.
..... *Original contour.* - - - - *Seaweed.*

at the surface of the water. The cliffs of Capri tell us in clear geological sign-language that the waves which dash up in storms can have taken but a small part in the etching of the groove. On the north side of the island calm has prevailed, and the grooving and undercutting are well marked; on the south, full exposure to the open sea has resulted in faster scaling from the face of the cliffs and in the obliteration of the groove of solution.

When rain and spray fall on flat limestone surfaces near the sea-level, solution is very rapid. The result may be seen in all stages, on many a partially submerged rock and boulder on the north and east coasts. The process is indicated in the diagram, which was drawn from an actual block of limestone (Fig. 1). The dotted line represents the original contour of the block. The portion below water has nearly retained its original dimensions, having been protected by a thick growth of algæ. At the water-line there is a groove of solution all round the stone; and the upper surface, which is undergoing rapid disintegration by rain and spray, is jagged and uncomfortable to walk upon. Soon all will be planed down to low-water mark, and then the kindly covering of weeds will hinder further destruction.

The furrow at the present water-level runs in and out of the older caves and cavities like a hollow moulding round the recesses of a building, and may be traced almost all round the island in the less exposed parts. This furrow is rarely more than a foot in depth; but where natural cracks or soft places in the rocks have favoured, the erosive action has been more extensive, and deeper hollows and little caves have been scooped out.

The Upper Erosion-line.—Similar marks of erosion occur at other levels above the surface of the sea. In some places they are as clear as if they had been cut yesterday, in others they have become almost covered up by newly deposited stalactitic matter; in the more weathered parts they have been entirely obliterated. Wherever they occur, they

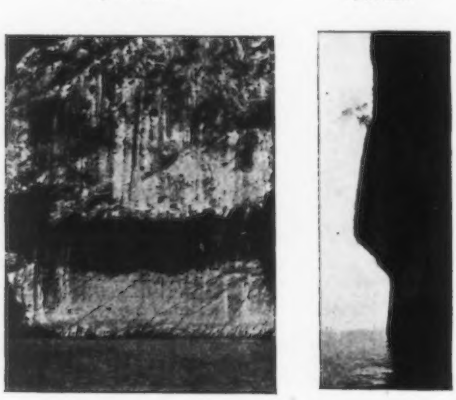

FIG. 2.—UPPER EROSION LINE ON LIMESTONE OF CAPRI.

afford an unmistakable indication of having been formed at and by the surface of the sea, and of having been subsequently raised beyond its reach.

At a height varying from 23 feet to 12 feet above the present sea-level, the island is girt about with a line of holes, grooves, and undercuttings which are similar in character to those at the present water-level, save only that they are less continuous. For these marks of erosion no other explanation can be offered, but that they were wrought by causes identical with those which have produced the groove at the present sea-level.

To explain the phenomena, two theories are possible. We may either believe, with Niccolini, that the sea-level in the course of ages has been subject to alteration, or that the land has moved. Of the two, we favour the latter; for whereas we are not aware of any proof of

change of sea-level, Capri is a geological monument to change of land-level. The originally horizontal beds of Tertiary limestone have been tilted so as to dip with an inclination which increases greatly from east to west. From the Faraglioni to Pta. Ventroso the beds dip at angles increasing from 25° to 35°; near the Green Grotto the dip is nearly 40°; while at the south-west corner the dip is as much as 60° to 70°.

It is not surprising, therefore, to find that this tilting has continued in the most recent period, and that the marks of the upper erosion-line lie in a plane inclined at an angle to the horizontal. In other words, the past and present marks of marine erosion are 23 feet apart at the eastern end of Capri, but only 12 feet apart at the western end. We cannot suppose that the sea has changed its horizon. The land must, therefore, have moved as if on a distant hinge 4 miles away to the west, and have turned through an angle of nearly two minutes of arc.

As will appear in the sequel, there is good reason to place the erosion of the upper water-line at a period subsequent to the Roman dominion, and this gives us a basis for a calculation of the rate at which geological changes of magnitude may take place.

We find that the changes in the relative level of land and sea have not been of a uniform but rather of a spasmodic character. All indications point to the land having remained nearly stationary for considerable periods of time, and of having then, in a relatively brief space, shifted to a new level. As a proof, we find that the marks of erosion are confined to narrow zones. The island, moreover, appears to have remained stationary in its present position for a shorter period than at the 23 to 12 foot level, for the upper marks are deeper and more conspicuous than those along the present water-level. Hence, if we may assume that the rate of marine erosion has been fairly uniform, we can estimate the relative duration of periods during which the land-level has remained constant.

Starting from the south-western corner of the island near the Pta. Carena, we find the upper line of holes, grooves, and undercuttings about 12 feet above the present water-level. It may be traced at various spots along the west coast, but, owing to the great extent to which the weathering of the limestone has proceeded, the marks are not as conspicuous as those along the northern and eastern cliffs.

In and near the Grotta Azzurra the same line of hollows rises about 16 to 17 feet above the water, and is continued within the grotto itself, thus proving that it was submerged, and inaccessible.

At the Pta. Sbrussa this upper erosion line is very noticeable, and, keeping approximately to the same level, small borings in the rocks can be traced nearly as far as the Pta. Trasele.

Further to the east, the massive walls of the so-called Bagni di Tiberio have been levelled nearly to the same height—a remarkable coincidence suggestive of a common cause.

Near the north-eastern cape, the isolated Scoglio Ricotta shows the grooving of the old water-line, but to the south-west of the Pta. Chiavica, in the vicinity of the Grotta Bianca, and at many places round the Cala di Matromania, the undercutting of the rock is seen in its greatest perfection and at its greatest height (23 feet) above the present water-level. Protected from erosion both by its height above the sea and by a foreshore of *débris* from the cliffs above, and in some spots painted over with a coat of preservative calcareous incrustation renewed continually, these low land* marks have perfectly resisted the destructive hand of time.

The marks of erosion may also be well seen upon the west side of the

FIG. 3.—UPPER LINE OF HOLES, NEAR PUNTA SBRUSSA.
About 18 feet above the water-line.

isolated Scoglio Matromania, which in this respect is a diminutive model of the entire island, for on the lee side the undercutting is well preserved, but has been weathered away from the side that is more exposed. The vertical cliffs of the Faraglioni and of the Monacone bear the water-marks of the same low land-level.

At several places along the coast between the Pta. Ventroso and the Pta. Carena, conglomerated beaches may be seen resting upon shelves of rock raised above the sea-level. Some of these are mere accumulations of *débris* which have fallen from higher levels, but

* Cp. "high water."

others owe their origin to the action of the waves when these beaches were on the sea-level.

When a cavity in the face of the rock has once come into existence, the unaided action of the sea-water cannot increase its size to any considerable extent, for the upper surface of the excavation above water would soon be out of reach of that element, and the floor would be protected by seaweeds. If, however, the level of the land should be elevated or depressed very gradually, a cavity already in existence at the earlier water-level would be enlarged. An elevation of the land would cause the floor of the cavity to rise into the plane of maximum erosion. Similarly, if the land-level be depressed, the roof would be eroded.

It is to the simultaneous action of these two processes of gradual alteration of land-level and of erosion that the larger caves of Capri owe their origin. The caves are, for the most part, wide-mouthed, and of no great depth as compared with their height and breadth. They are of the type we may term sea-caves, as distinguished from stream-caves which have been produced by the flow of fresh water, like the lengthy subterranean passages with many lateral embranchments in Kentucky and Carniola, of which there are no examples of any size in Capri. Nor, indeed, is the present surface of the island large enough to collect rain-water for the erosion of its lofty caves, attaining as they do a height of 60 feet and more. I am inclined to accept the proportions of the caves as strong evidence that in recent geological epochs, Capri did not receive the drainage from an extensive land surface for long, but was either an island, as it is now, or the extreme end of a narrow promontory.

Evidence of Land-levels to be derived from Caves.—A type of the many smaller caves at the water-level is the Grotta del Lupo, which is known for the gurgling noises which the waves produce in its confined recesses.

A similar cave is the Grotta degli Stalactiti,* between the Marina Grande and the Blue Grotto, and accessible only to the swimmer, owing to the low entrance. The long stalactites hanging from its roof bear witness to a long period of tranquillity within, for spray would have prevented their formation.

Passaggio della Stella.—As an example of a more extensive result of marine erosion, we may cite the passage through the Stella or inner Faraglione rock, which is large enough for fishing-boats to sail through. The height of this passage corresponds to that of the low land-level, which is clearly indicated by the undercutting upon the sides of the Faraglioni themselves. The floor of the passage is far below the

* There is another Grotta degli Stalactiti high up upon the side of the hill of St. Michele, near the church of St. Croce.

surface of the water. At the east end the depth of water is 13·08 metres; in the middle, 18·38 metres; and at the west end, 19·30 metres.* We believe that these soundings indicate that the Faraglioni once stood at least 13 metres higher above the water than they do now.

Grotta Azzurra.—The precipices of Anacapri fall into the sea from a height of some 600 feet, and the sheer rock is continued beneath the water for a further 120 feet. Towards the west this wall of limestone does not rise as high above the water, although the adjacent soundings are still so deep that the 100-metre isobathic line approaches to within

FIG. 4.—THE FARAGLIONI.

(*From a photograph by Brogi.*)

The arrow indicates the upper erosion line, best seen between Stella and Scopolo, about 23 feet above the water-line.

200 metres of the shore, closer than at any other point round the Bay of Naples, and only surpassed at the Pta. Carena.

Here, under cliffs of no great height, but above water of great depth, is the chief glory of Capri—the Grotta Azzurra.

The present entrance to the cave is of the size and shape of an ordinary doorway, but, inasmuch as some 3 feet of this entrance are under water, an aperture barely greater than a yard square remains

* These soundings were taken in the middle of the waterway at my request, on October 4, 1902, by our vice-consul, Mr. Harold E. Trower.

above water for the passage of the diminutive boats specially built for the navigation of the grotto. The floor of the entrance projects outwards for several feet, forming a platform. The passage is only possible in a calm sea, although the water within is stated to remain tranquil by some who have been caught there during a storm. From without the aperture is hardly discernible; and indeed, were it sufficiently large to admit any great volume of light, the glory of the grotto would depart. In fact, the blueness is seen to the greatest advantage when a screen intercepts the direct light from the entrance.

The discovery of the grotto in recent times is frequently attributed either to a fisherman, Ferrara by name, and two Englishmen in 1822, or

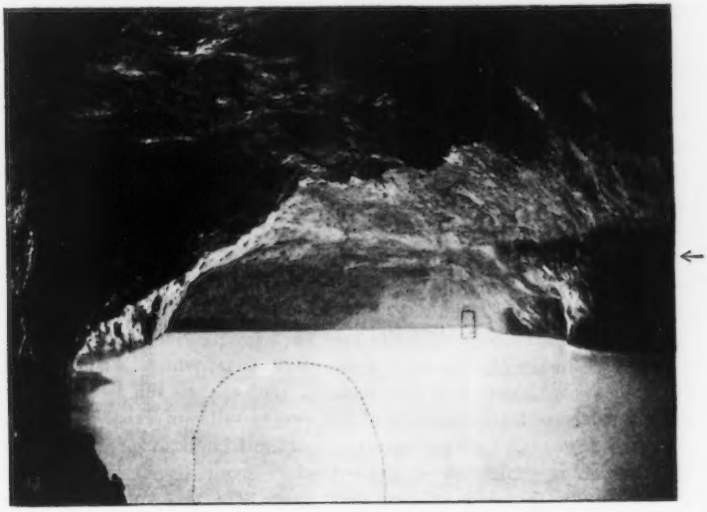

FIG. 5.—THE BLUE GROTTO.

(Adapted from a photograph by Sommer.)
The dotted lines represent the positions and relative sizes of submarine arch and entrance. The arrow marks the upper erosion line, here 17 feet above the water-line.

to Kopisch in 1826, who wrote a fantastic account of his exploration, and of the difficulty of allaying the superstitions of the fisherfolk with regard to it. It is to this little narrative of Kopisch that the great fame of the Blue Grotto owes its birth. For the real discoverer, however, we must go three centuries back to Capaccio, who mentions it in his History of Naples of 1607. In 1701 it was visited by Joseph Addison; and in 1727 Parrino attributed its peculiar character to the reflection of light.

The grotto is oval in shape, the major axis running east and west. The dimensions are—length 165 feet, breadth about 100 feet, greatest

height 40 feet, depth of water 48 feet.* Mangoni gives the dimensions as 170 by 90 by 69 by 69 feet.† The discrepancies are, as might be expected, greatest in respect of the height. The lower estimate of 40 feet seems to us nearer the truth than that of 69 feet, and a large proportion of the vault of the grotto is not much more than 20 feet above the surface of the water. The sides of the cave descend vertically into water which is about 8 to 10 fathoms in depth.

At the side on the right of the entrance to the north-west is a second but entirely submerged opening. The crown of its submarine arch is about 7 or 8 feet below the surface, the width of the opening is about 40 feet, and its height about 50 feet. By this submerged window the grotto receives its wonderfully beautiful light, and it is near the arch that the water has the brightest silvery-blue sheen.

The early explorers were much surprised to discover that they were not the first to enter the grotto. Towards the centre of the back of the cave they found an artificial flight of steps, somewhat broken,‡ leading from below the present water-level to a rocky ledge 3 feet 6 inches above. This ledge is the threshold of an inclined passage which continues some 300 or 400 feet into the rock in a southerly and upward direction. No vestige of building, no tool-marks have been traced upon its walls, and so we must assume a natural origin, probably by aqueous solution of the limestone. The floor consists of a pavement of stalagmitic matter. At first the passage is high enough to be walked along comfortably, but it becomes lower and narrower and several degrees warmer§ as it ascends. In the last part progression is difficult, and the way is finally blocked by a square-cut stone, which is supposed to indicate a continuation of the passage, perhaps, to the vaults of the ruined palace of Damecuta, one of the twelve villas of Tiberius.

Such, then, is a general description of the Blue Grotto. The indications which it affords us of ancient water-levels are firstly a number of hollows in the sides of the cave just under the springing of the vault, at a height of 16 or 17 feet above the sea (Fig. 5). These holes are a memorial of the 23 to 12 foot land-level, the level at which the Blue Grotto was finally excavated to its present height.

Next, the ancient steps, continued as they are far beneath the water, indicate a higher land-level at the time of their construction. Where they cease I do not know, but I have heard it stated that they lead down for 20 feet to what we shall consider to be the water-line at the time of Tiberius, and it is very likely that this was the fact. The

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* Murray's 'Handbook for South Italy.'

† Reduced from Neapolitan *palmi*, 10·4 inches being taken as 1 palm. Another observer gave 160 by 85 by 50 by 65 feet.

‡ The old Roman steps were renovated about 1890.

§ The thermometer has been observed to indicate a temperature of 100° Fahr. when the temperature outside was only 88° Fahr. (Mangoni).

large aperture would then have allowed free entrance to boats, since its arch would have been at least 12 feet above the surface. It is certain that the Romans knew of and used the cave; it is equally certain that no mention is made of its optical phenomenon by classical authors: the conclusion to be drawn is that the conditions of illumination were entirely different from those of the present day. The cave must originally have been eroded when the land stood at a level higher than at present; perhaps by some 60 feet. A gradual sinking of the land through 40 or 50 feet, followed by an elevation to the Tiberian level, would be sufficient to allow of the erosion of a cave such as the Romans knew.

Grotta Verde e Passaggio Verde.—Near the Green Grotto the coast is rugged and weather-beaten, being fully exposed to the fury of scirocco gales; the wear and tear of the rocks is very rapid, and the marks of former water-lines are not likely to be long preserved. Consequently it is difficult to recognize any definite indication of former land-levels in the Green or the adjacent Red Grottoes. All that can be definitely stated concerning them is that they are sea-caves, the floors of which, formed when the land was higher, are now submerged, but the roofs were eroded when the land was at a level lower than the present by about 20 feet.

The green light upon the rocks seems to be a composite effect due to blue light reflected and transmitted from the water, playing upon the yellowish-hued sides and roof of the cave. It is best seen in the lower Passaggio Verde, which may be traversed by boat on a calm day.

Grotta Bianca.—The White Grotto derives its name from the white incrustations of calcareous matter upon its sides, and from the clusters of white stalactites which hang from the roof and fringe the entrance. The cave faces east, and is situated near the Pta. della Chiavica. The vestibule, about 70 to 80 feet high, leads into upper and lower caves, of which the former is not easily accessible. There is no record of its having been visited at all before Lieut. Kennedy, R.E., in 1901, by sending a boy up the long yard of a lateen-rigged boat, which was moored alongside, got some ropes fixed into it. He was thus enabled to climb up.

The lower cave can be entered by boat for a short distance. Unlike most other caves at the water-level, it is much broader at some 6 feet above the water than actually at the surface. The total height is not great in proportion, being only 24 feet or less.

The upper erosion-line is very clearly marked near this cave, and is also noticeable within it. The upper cave seems to belong to an earlier period.

Grotta dell' Arsenale.—This cave owes its name to a tradition that it was used in the time of Tiberius as a depôt for naval stores. It measures 130 feet long by 100 feet wide by 50 feet high. Excavations

made in 1777 in the shingle, which still covers the floor to a depth of from 4 to 5 feet, brought to light traces of the walls of two or three rooms of Roman workmanship; a floor of coloured marbles, and some iron fragments which have been identified as part of the plant of the ancient naval station, or perhaps of a Roman galley. Although the floor of the cave is quite 8 feet above the sea, in southerly gales waves dash in with such violence as to render its use as a storehouse out of

FIG. 6.—ARCO NATURALE.
(*From a photograph by Brogi.*)

the question. The walls unearthed here indicate, therefore, that at the time they were built this cave stood higher above the sea than it does at present, and the conformation of the rocks is such that an elevation of 15 feet would place the floor beyond the reach of all but the most exceptional storms.

The cave itself seems to have been formed by marine erosion when the land-level was at least 8 feet lower than it is at present—at a period which must have been much anterior to that of the Roman times.

As evidence of a still greater submergence of Capri, we may mention those large and lofty caves which are found at a height sometimes of 700 feet above sea-level. All are relatively shallow, and appear to be the result of marine erosion. It is difficult to estimate with any accuracy the time required for so great an upheaval. We can only know that it is so recent that the combined forces of wind and weather have not succeeded in obliterating all traces of marine erosion.

Arco Naturale, Grotta di Matromania.—High above the sea, on the steep pile of rocks which rises from a small cove facing east, is a most remarkable natural arch, which, like the passage through the Stella, seems to have been eroded by the sea.

At a little distance from the arch is the Grotta di Matromania, Mitromania or Matrimonio, a large natural cavern of about 90 feet long by 60 feet wide by 60 feet high, which seems to have been a fane of Mithras, whose name the grotto still bears.

The Grotta del Castiglione is a lofty cave high up in the hill of the same name, facing south. When the inhabitants of Capri took refuge in it at the time of the Turkish raids there was a way to it from the east, but the path has since been destroyed by the crumbling of the cliff.

Grotta dell' Arco.—A large shallow cave facing east, under the cliffs south-east of the Castello di Barbarossa. In height it is about 85 feet, and it is situated at about 800 feet above sea-level. We are not quite satisfied that the Grotta dell' Arco is a sea-cave, and rather incline to the belief that it may have arisen as a result of the great landslip which occurred at the east of Monte Solaro.

Other similar elevated caves are the Cocuzza, Tiberio, Grotta delle Felci, and others under Monte Solaro.

It might well be argued that such a great alteration in the level of Capri as that supposed must have to some extent affected the neighbouring mainland, and we find that on the hillsides of the Amalfi coast there are also large caverns, similar in appearance, situation, and aspect to those we have just enumerated.

Evidence of Land-levels to be derived from Ancient Buildings.—In many places around the coast of the Bay of Naples, Roman ruins are to be seen very near the water's edge, and, if not dipping in the sea, often so close to it as to be exposed to the ravages of every storm. In accordance with the theory of alteration in land-level we believe that the buildings were originally constructed and occupied at a higher level, and have been carried down by the land as it subsided. Such buildings may, therefore, afford us valuable assistance when we endeavour to date the land-movements and to estimate the time of their duration.

Palazzo a Mare.—By far the most extensive Roman remains upon the Capri littoral are those known as the Palazzo a Mare, one of the

largest of the twelve villas of Tiberius, and therefore dating from about 27 to 37 A.D. The buildings not only covered considerable ground on the top of the cliffs, which were buttressed by strong walls, but also extended down to the beach, where the north wing was thrown out towards the sea, and must have made a charming abode in summer. As seen from the sea, a semicircular exedra of *opus reticulatum* halfway up the face of the cliff is one of the most conspicuous features of the ruins. It is built so as to cover the middle third of the height of the cliff facing Vesuvius. Many fragments of walls lie in the water below, having been undermined by the sea; but as they have fallen from uncertain levels, they do not supply us with data as reliable as those to be derived from the western portions of the building still *in situ*.

To the north-west of the exedra, and standing partly upon a little beach, partly in the water beyond, are more remains of this northern wing of the palace, the massive ruins well known to the boatmen as

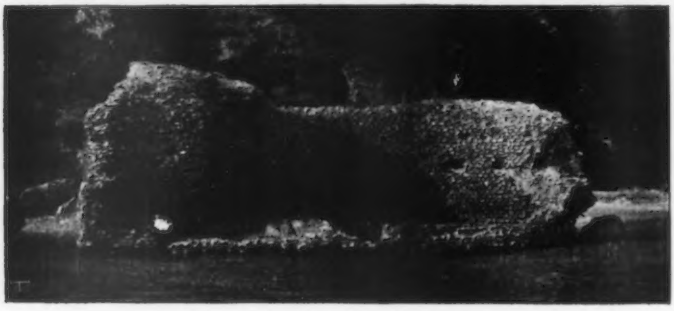

FIG. 7.—BAGNI DI TIBERIO. SOUTH WALL.

the Bagni di Tiberio. The best-preserved portions are the lower walls of a large rectangular room, measuring about 50 feet from east to west, which seems to have been open on the east. The southern wall, curved and apse-like in shape, is all built of limestone (*opus incertum*), except one small course of tufa, which may be seen near the upper part of the east end of the wall. The greater part of the top has been levelled to a height of about 15 feet from the present surface of the water (Fig. 7), but the east end stands up some few feet higher. It has already been suggested that the wall was cut down to the present height at the time of the erosion of the 23 to 12 foot groove. The north and west walls, being more exposed, have been much more worn away, notwithstanding their remarkable thickness of 27 feet. The inner 15 feet are of limestone, and appear to be of the same age as the south wall; but at a later date an outer casing of tufa of about 12 feet was added, perhaps against the encroachments of the sea.

The original pavement of the room, about 1 foot above the present

surface of the water, has been almost wholly washed away, thus exposing a drain, which opens on the north wall at about 6 feet under water. The existence of this drain, as well as of pipes running in the walls—one near the north-west angle is continued for 7 feet below the surface of the water—is clear proof of the subsidence of the buildings. Near by are portions of walls belonging to other and smaller rooms less well preserved and also under water. The partial submergence of these walls has led to the belief that the lower part of the building was originally used as a sea-bath—an interpretation which is commonly given for other partially submerged Roman buildings round the Bay of Naples. Now, although some of these submerged buildings may have been built as bathing-establishments, we must be cautious in accepting any interpretation depending solely upon the present level, for often the structural characters of the ruined walls show them clearly to have been built well above water.

Cloaca.—The end of a Roman sewer may be seen at the west of the Grande Marina. It seems to have drained a considerable part of the northern side of the island, to judge from the discovery of many smaller drains which are believed to have led into it. The fall of the sewer has been greatly changed. Instead of having a gentle gradient from south to north, it now dips steeply in the reverse direction, viz. north to south at an angle of 25°. This reversal of incline has occasionally been cited as evidence for the alteration of the land-level of Capri since the Roman period. And such evidence it undoubtedly is, but the large angle through which the drain has been tilted, the broken nature of the end of the cloaca, and the occurrence of perfectly undisturbed and upright ancient walls at no great distance, point to a change of level more local and violent than those gentle and widespread earth-movements which are the more immediate subjects of our paper.

The dislocation of the sewer was probably the result of a landslip which did not affect the land on either side. The walls of the Palazzo a Mare, though now standing at a lower level than when first built, are still plumb, which could hardly have been the case had they been involved in the landslip. Again, on the other side of the cloaca, the old Roman aqueduct near the middle of the Grande Marina has preserved its form and level sufficiently to be still carrying off the overflow waters from the fountain. The aqueduct, however, seems to have suffered from earthquakes, as does a large building which was discovered near the fountain in the reign of Francis I.; the walls were badly cracked, and the vaulted ceilings were found to have fallen.

An explanation for the remarkable tilt of the cloaca which is given by some writers on Capri is that since it was laid, the subsidence of a large area (between San Michele and Mte. Solaro) has taken place. Indeed, Captain Mackowen has gone so far as to make a calculation, from which it would seem that the land near the watershed above the

cloaca must have sunk 150 metres to produce the required inclination. But we doubt whether it has been proved that the sewer continues in a straight line for a great distance and at the same tilt. It is more likely that the terminal portion of the sewer only has slipped and taken a steep inclination. Therefore we cannot fairly argue about the direction of the earth-movements over such a large area as is involved in the calculation of Mackowen.

The Ancient Harbour and the Theory of Subsidence.—No discussion of the data relating to the ancient sea-levels of Capri would be complete without some mention of the ancient harbour which was used during the period of the Roman occupation of the island, since the two subjects are closely connected.

At the present day the traffic of the island is chiefly carried on on the north side, under the shelter of a little modern breakwater jutting out from the Marina Grande. The anchorage is anything but safe. On the southern shore there is no anchorage at all, for the deep water comes close to the rocks, and so the few fishing-boats kept at the Marina Piccola have to be hauled up.

Now, Suetonius * distinctly refers to the existence of a port of Capri, and of one only. The breakwater of the Marina Grande did not exist, nor have any other ancient harbour works hitherto been pointed out on the northern side. Mangoni and others have tried to show that the harbour alluded to by Suetonius, which the needs of an Imperial household in residence rendered necessary, may very probably have existed on the south coast.

The site which is the first to suggest itself to the hydrographer is the Porto Tragara. This little cove is thoroughly sheltered on the north by the island, on the west by the Pta. Tragara, and on the south-west by the Faraglioni; on the other hand, it is open to the south and east, and the rocky islet Monacone is a very insufficient barrier against the full force of a scirocco. Certain archæologists have accordingly expressed a view that a breakwater must have extended between the inner Faraglione and the Monacone, and that this has been destroyed either by subsidence of the land, earthquake, or marine erosion. The soundings between the rocks, however, do not tell in favour of this view, the water near the middle of the supposed barrier being close upon 25 fathoms deep. There is no clear evidence of any cataclysmic subsidence having occurred here in recent times; indeed, the fact that the upper water-line upon the rocks is in a uniform plane tells against the theory of local and sudden subsidence.

On the other hand, there are remains of large masonry walls, which are said to extend down to a depth of 22 feet near the Punta Tragara,

* "Quod uno parvoque litore adiretur, septa undique præruptis immensæ altitudinis rupibus et profundo mari."—Suetonius, 'Tib.,' 40.

on the western side of the supposed harbour. Lead pipes for the purpose of leading down drinking-water from reservoirs above have also been found, and they, together with the discoveries in the Grotta dell' Arsenale, are all evidence corroborative of the existence of a naval station of some sort.

If it be granted that the land stood higher out of the water in Roman times than at present, it follows that the anchorage would have been less deep, the water-passages between the rocks narrower, and the harbour more sheltered from wind than at present. But still we doubt if the Porto Tragara could have been rendered safe in all weathers without the construction of a breakwater to the Monacone. The foundations of an engineering work of such dimensions could hardly have entirely disappeared. Some traces would assuredly have resisted the encroachments of time, even as other Roman works in not less exposed situations have done. Roman galleys may have had moorings there during the season of settled and tranquil weather, and for this purpose the natural protection afforded by the three rocks (it has been suggested that Tragara = Τριάκρα) may have been increased by some arrangement of floating booms between them, so as to mitigate the force of the waves. But until conclusive evidence of traces of the breakwater are forthcoming, we prefer to disbelieve that the Porto Tragara was ever made a safe anchorage.

There are many indications that the land is at a lower level than when the submerged walls were built. West of the Pta. Tragara, and near the Unghia Marina or Albergo dei Pescatori, a flight of steps, partly masonry, partly cut in rock, may be perceived about 10 or 12 feet below the water. These must have been above water at the time of their construction.

A little further west, on the tiny beach known as the Marina di Mulo or Piccola Marina, are submerged Roman constructions which were considered by Mangoni to have formed part of the Mulo or mole, and of other works of the naval station, which he believed to have extended from the Pta. di Mulo to Tragara. The depth of the water is certainly far more favourable for breakwater construction than at Tragara, and it is possible that some ancient works may lie buried beneath the shingle and *débris* of the Marina Piccola, but it is highly improbable that the principal harbour would have been on the weather side of the island. Beloch has taken the view that the "one small shore of access" was the Marina Grande. While doubting his premise that the modern breakwater has rendered the Marina Grande an entirely safe harbour, and that therefore it must also have been safe in the days of the Romans, we agree with him in believing that the ancient town of Capreæ would have stood near the landing-place, for it was founded by a sea-faring people. The ancient Greek steps leading to Anacapri, and the old cathedral of S. Costanzo, of the first century A.D., are both

valuable indications of the position of the old town. And we find an additional support for the view in the local tradition that the lower town had to be deserted because proximity to the sea rendered it subject to the raids of pirates.

All this evidence is strongly in favour of the principal landing-place being on the north side of the island, and it is there that we are inclined to seek for traces of it. Lying submerged in the beach and sea are some large squareish masses of masonry, which are commonly stated to be the end of the cloaca. But in their arrangement and appearance these structures are so like the breakwaters of the Roman harbours of the mainland (*vide infra*), that we have no hesitation in identifying them as the western mole of the ancient harbour of Capri, which has become filled up with sand and *débris* from the cliffs above. Doubtless the landslip which dislocated the cloaca contributed to the obliteration of the harbour. The upper part of the mole would, of course, have stood high above the water in the Tiberian period.

Conclusions with regard to the Movements of Capri.

1. Whereas there is abundant evidence that the land of Capri has undergone very considerable changes in position, there is no evidence that the level of the sea has altered.

Therefore all former water-lines are more logically interpreted as indicating changes in the level of the land rather than changes in the level of the sea.

2. The land has remained nearly stationary at its present level for a period long enough to allow of the formation of the marks of erosion along the present water-line.

3. At some previous epoch (post-Roman) the land also remained stationary in a lower position at the level indicated by the 23 to 12 foot water-line, *i.e.* the land has risen 23 feet at the east end, but only 12 feet at the west end of the island.

Effects—Erosion of upper water-line.
Levelling of walls of Bagni di Tiberio.
Erosion of roof of Blue Grotto and of interior of lower White Grotto.
Erosion of arch of Stella.

4. The Tiberian land-level was about 20 feet higher than the present. The land must have been at a level sufficiently high to raise the large aperture of the Blue Grotto partially above water, and to lift all low sites with Roman buildings, such as the Grotta Arsenale, sufficiently to make them suited to their purpose.

5. At a still earlier epoch the land must have been at a level high enough for the erosion of the floors of the Blue Grotto, of the Stella passage, and of all other partially submerged caves.

6. The land must have been at levels low enough for the floors and

roofs of all elevated sea-caves to have been awash. Thus the land must now stand higher by the altitude of the caves above sea-level.

Effects—Erosion of floor of Grotta Arsenale, and of widest part of Grotta Bianca.

Erosion of upper cave of Grotta Bianca.

Erosion of Cocuzza, Grotta Matromania, Arco Naturale, cave at Amalfi, elevated caves under Monte Solaro, etc.

II.—THE SORRENTINE PENINSULA.

The Sorrento of to-day is perched high above, but overhanging, the sea on the edge of a tufa plateau, which lies in a cradle of limestone hills. The sea, ever gnawing into the foundations of the tufa, has helped to produce a perpendicular escarpment, in consequence of which the plain of Sorrento falls away to the north abruptly in vertical cliffs, some hundred feet in height.

Here and there the torrents from the mountains behind have left great ravines in the tufa, which, like the valleys in the Camaldoli hills, are cañon-like, with nearly vertical walls.

Under the cliffs are a few beaches separated by intervening water of no great depth, covering a sandy bottom. Below Sorrento itself, one of the more extended beaches is used as a landing-place, and is protected by a quay and a breakwater, inside which a few vessels can find shelter on what would otherwise be a dangerous coast in certain winds.

The Lower Town.—In times gone by the sandy shore was more extended than it is to-day. Fishermen tell how it was once possible to walk dryshod beneath the steep rocks from the Grande Marina to the Piccola Marina. More positive evidence is afforded by the many foundations and walls of ancient buildings which now lie submerged beneath the town, but which must originally have been built on dry land. Their splendour is indicated by the almost inexhaustible supply of fragments of fine marbles and mosaics which are thrown up on the beach after every storm.

An entire suburb of the Roman Surrentum seems to have stood on the strand at the foot of the cliffs, between the two Marine, and to have stretched as far east as the Punta di Circe. Among others which have been traced were a room of *opus reticulatum* with a mosaic floor, now destroyed by the Calata of the Villa Tre Case (Hotel Croce di Malta); foundations of *opus lateritium*, on which the custom-house of the Piccola Marina now stands; the foundation of a rectangular building now under water, and many broken cipolline columns used for mooring vessels at the Piccola Marina. In the direction of the monastery of S. Giorgio, four other buildings may be seen beneath the sea, in water which is there but a few feet deep.

The many artificial caves also bear witness to a more extensive foreshore.

A typical one is the Grotta di S. Giorgio, which, owing to the subsidence of land, has now to be visited by boat, the floor being 1·1 metre below water. The ceiling is vaulted, and there is a niche in the end wall. Although commonly called a "bath," there is a tradition that this grotto was once used as a "church."

In ancient days the commercial centre of the town was probably here close to the magazines and warehouses, and near by must have been the Temple of Venus which is mentioned in the lines—

> "Adsis, o Cytherea, tuus te Cæsar Olympo
> Et Surrentini littoris ora vocant."
>
> Pseudo-Virgilian Epigram, Catal. vi.

Bagni della Regina Giovanna.—We have at the Capo di Sorrento what may be considered a monument to the changes in land-level, in the ruin popularly known as the Bagni della Regina Giovanna, but undoubtedly a Roman building on the property of Pollio Felix. It is worthy of attention, for it gives us more positively than do the Roman ruins at Capri, the approximate period within which the land remained at the low level already referred to as the 23 to 12 foot level of Capri.

This building is doubly interesting, because it seems to be one of the very few on the Bay of Naples of which we have any description in classical literature. The romantic position provoked the admiration of Statius, and called forth the lines—

> "Dat natura locum montique intervenit unda,
> Litus et in terras, scopulis pendentibus, exit.
> Gratia prima loci gemina testudine fumant
> Balnea, et e terris occurrit dulcis amaro
> Nympha mari. levis hic Phorci chorus, udaque crines
> Cymodoce viridisque cupit Galatea lavari."
>
> Silv. ii., 2, 15-20.*
>
> "Curvi tu litoris ora
> Clausisti calidas gemina testudine nymphas."
>
> Silv. iii., 1, 100.*

A narrow passage leads from the sea, under a rocky arch, into a round basin filled with crystal clear water. The basin is surrounded by a rocky wall, about 40 feet high, and may once have been a natural cave in the limestone, of which the roof has fallen in. The Romans lined it with masonry and vaulted it over. The *gemina testudo* has fallen, leaving the bath open to the sky, and large fragments of masonry may be seen lying at the bottom of the pool.

We believe that this building originally stood higher above the sea than it does now, because the springing of the vault near the entrance

* Other texts have "lympha" and "lymphas" instead of "nympha" and "nymphas."

shows that the ceiling, if perfect, would be nearer the present surface of the water and the room lower than a sense of good architectural proportion demands. If we may assume that the height of the bath was originally in a good proportion to the width, as it is in the other similar round buildings at Baiæ, etc., we have an indication that the land here is lower than it was when the building was erected. Con-

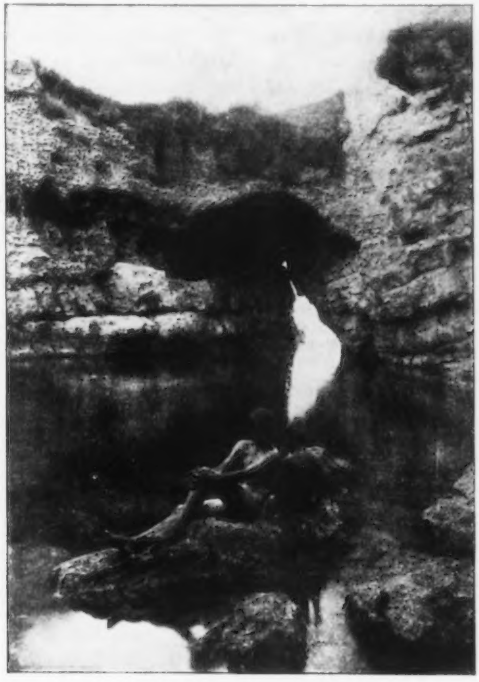

FIG. 8.—BAGNI DELLA REGINA GIOVANNA.
(*From a photograph by Plüschow.*)
The arrow indicates the upper line of erosion, 18 feet above the present water-line.

firmatory evidence is afforded by a strongly marked undercutting of the rock walls of the entrance, now at a depth of some 16 feet under water, which we believe to be due to abrasion by shingle. There is also a slight undercutting on the sides of the entrance, at about 5 feet below the surface of the water.

Convincing proof of post-Roman rise of land-level is also to be found upon the building, for at 18 feet above the water-level, near the springing of the vault, is an upper line of erosion marks. The same line

may be seen at various places along the north side of the promontory, and also below the Martello tower round the point.

Our conclusion is, that the building known as the Bagni della Regina Giovanna was at least 16 feet higher above the sea-level, and instead of containing deep water may even have had a dry floor, and have been used as a hall or apodyterium in which bathers could lounge between their baths.

While the land was still standing at this level the sides of the entrance were worn away by the shingle rolled by the waves. The land then sank 34 feet, remaining stationary for a brief space after it had sunk 11 feet, thus allowing for the second undercutting. The upper line of erosion marks was then made, and the land has since been raised 18 feet, and has remained there for some time. The oscillation has, in fact, been similar to that of Capri and of the temple of Serapis, and to one which has affected the mainland as far north as Gaeta,* but the magnitude of the movement has varied somewhat in the different localities.

Submerged Caves between Sorrento and Meta, believed to have been Ancient Quarries.—Under the tufa cliffs between Sorrento and Meta are some large and partially submerged caves. In the Grande Grotta nearest Meta, the depth of water is from 4 to 5 metres, both in the main chamber and in the small side entrance of the cave; the bottom is sandy. Outside the cave the depth of water is 6 metres at a distance of some 4 metres from the cliffs.

The next cave has two entrances, narrower and lower than those of the first. The water is 4 metres deep. In the third cave the depth of water is 5 metres. The next, the Grotta della Campana, has a broad beach 23 metres long, and the general appearance and inclination of the walls lead one to believe that the cave was originally lower, but not much less spacious than the other caves, but that it has become partly silted up.

Now, the tufa rock does not become eroded in such a manner as naturally to give rise to spacious caves, and consequently we believe these large caves below the plain of Sorrento to have had an artificial origin. An elevation of 5 metres would place their floors above water, and would make it possible for a cart to pass along the foot of the cliffs to the seaport, and so the conclusion is that they were quarries whence the Romans drew the hard tufa of good quality for the many buildings which stood upon the then extensive foreshore.

Evidence of Former Land-levels from the Amalfi Coast.—It is only to be expected that the southern shore of the Sorrentine peninsula should have accompanied the northern in its alterations of level, and

* The peculiar shape of the mushroom rock at Lacco, Ischia, seems to be partly due to the same low land-level.

the elevated sea caves have already been explained as the result of the same low land-level as that of the elevated sea-caves of Capri.

To Amalfi, the headquarters of the Eastern trade in the eleventh century, and perhaps also to the juxtaposition of the University of Salerno, we owe one of those rare early records of subsidence which help us to fix the dates of the post-Roman earth-movements. The submergence of the greater part of a town of 50,000 merchant-mariners, who steered by the compass,* was not an event to be left unrecorded by the chroniclers,† and so we learn that the "inundation" of Amalfi occurred before 1140, the date of Andrea Mola, and probably after the period of the greatest prosperity of the city. No wonder that after such a catastrophe, though gradual, the city was not able to withstand the arms of the Normans, and finally fell a victim to the ambition of Pisa.

III. COAST OF POSILIPO.

The next portion of our evidence has been derived from the coast of Posilipo, which we have studied with the object of ascertaining, as nearly as may be, both the actual level of the land during the Roman dominion, and the form of the ancient coast-line. Except at the end nearest to Naples, where the natural contours have been much disguised by buildings, the structure of Posilipo may be easily perceived.

The tufa slopes of Posilipo are seamed like a well-drained field, with ridges and furrows running at right angles to the long axis of the ridge, which extends from north-east to south-west. The coast-line is undulating; little coves or *cale* alternate with diminutive headlands, corresponding respectively to the furrows and ridges of the slopes. The beds of tufa are of varying hardness, therefore the progress of erosion has been very unequal. The detritus from the cliffs forms sandy beaches in the *cale*, and all sheltered spots, such as artificial harbours, tend to become rapidly silted up with sand drifted along the shore from south to north. At no place is the water near the shore very deep, and the 3-metre line of soundings is far enough from the base of the cliffs to admit the possibility of a road, if the land were raised a little above its present level. A rise of only 6 feet would make it possible to walk along the shore from the town to the Capo di Posilipo.

The Upper Erosion-line.—At many points along the shore the upper groove of erosion is very marked. It does not preserve that absolute straightness which we have noticed in Capri, where the limestone is of

* ". . . hac plurimus urbe moratur
Nauta maris cœlique vias aperire peritus."
Gulielmus Apulus, iii. p. 267.

† "Civitas Amalphia erat major ut est in præsenti, quia major pars ipsius propter inundationem maris est deleta et jacet intus mare," quoted from Andrea Mola di Tramonti by Niccolini. The event has been recorded in verse by Matteo Camera.

uniform hardness; the course of the groove, being partly determined by variations in the hardness of the beds of tufa, rises and falls, so that it is often difficult to determine the precise position of the land-level at the time of the greatest depression. Above the groove of erosion the surface of the rock is honeycombed by weathering, below it the rock surface is fairly flat, an instance of preservation by immersion.

Effects of Subsidence.—Our evidence that the land is at a lower level than in classical times is chiefly derived from the many Roman buildings which lie submerged along the shore.* There are rooms with floors awash or beneath the surface; ancient plaster is to be seen still adhering to submerged walls, and passages tunnelled through the rock

FIG. 9.—TUFA CLIFFS ON EAST SIDE OF NISIDA.

Showing the difference between a surface below the upper erosion line, which has been preserved by submergence, and a surface above, which has been weathered.

are now entirely filled with water. It is necessary to enlarge upon these submerged ruins, because they have generally been regarded merely as foundation walls thrown out into the sea for baths, landing-places, and other such purposes, and that, therefore, they are not to be regarded as evidences of the subsidence of land.

We disagree with this view, though acknowledging that some of the structures furthest from the shore and in the deepest water may have originally been erected in the sea, like the works referred to by

* Described in a paper read by the author before the Society of Antiquaries on January 22, 1903, and shortly to be published in *Archæologia*.

Horace, "Although possessed of greater wealth than the untouched treasuries of the Arabs and opulent India, you were to overspread with your piles of rubble all the Etruscan and Apulian sea. . . ."*

The work of exploration was not easy: it is always difficult to make out the true form of objects under water even in a dead calm, and in a slight breeze impossible without a water-telescope. Reflection and refraction conspire against the observer. Nor are they his only *bêtes noires*. Currents may drift boats and buoys from their stations, and disturb orientation. If buoys left to mark positions be not carefully watched, some meddling fisherman may move them or "lift" them altogether. Once, when sounding between the ancient piers of the harbour of Misenum, my operations were stopped by a suspicious coast-guard officer; and last, though not least, the gas-lit buoy which marks a dangerous shoal off the end of Posilipo was moved by an officer of the port of Naples from the place indicated on the charts of the Uffizio Idrografico, thus rendering a number of position angles based upon it worthless.

Most of the work was done in the early morning, before the day wind ruffled the surface of the sea. Lines of corks at measured intervals were floated on the surface vertically over the walls to be measured, and their positions were fixed with the help of a theodolite on land. Much assistance was derived from the local shore-fishermen and divers for shellfish, whose livelihood depends largely upon an intimate acquaintance with the *chiane* and *scogli* (shoals and rocks), presently to be described as Roman ruins.

Throughout we were impressed by the good state of preservation of many of the ruins, which shows that next to no erosion takes place at a small distance beneath the surface.

We believe that we can demonstrate that the principal effects of the subsidence of the Posilipo foreshore are—

1. The submergence of considerable tracts of land upon which many Roman, and probably Greek, buildings were erected.

2. The destruction of the ancient coast-road between Puteoli (Pozzuoli), the submerged regions, and Neapolis.

3. The flooding and isolation of the ancient quarries near the southern extremity of Posilipo.

4. The sinking of an ancient harbour, so that the breakwaters are now covered by 2 fathoms of water, and are therefore useless.

1. *The Ancient Buildings on the Foreshore.*—The most perfectly preserved of the ancient buildings which are now actually washed by the waves, but which must have been high and dry during the Roman period, is the Casa degli Spiriti. There are some 6 to 8 feet of water in the basement now, although at the time of the lowest land-level

* Od. iii. 24; *cf.* also Od. ii. 18, and Od. iii. 1.

the water reached high up the walls of the first floor, and has left an erosion-line inside the rooms at a height of 16 feet above the present level. It is astonishing that this house should have survived so many

FIG. 10.—LA CASA DEGLI SPIRITI.

centuries, but of its antiquity there can be no question, since the erosion-line and the *opus reticulatum* of which it is built are sufficient to convince the geologist and the archæologist independently.

A still larger Roman house once stood upon the beach below the fishing village of Marechiano. The walls of the ground-floor rooms are still standing, but the greater part do not reach the surface of the water. A few of the apartments have been used by fishermen as aquaria for keeping live fish, and so a tradition has arisen that in these ruins we have the remains of the fish-tanks of Vedius Pollio, and doubtless many a franc has been earned by the cicerone who could point out the particular tank in which were kept the pampered murænas that were fed upon slaves. However, other artificial constructions in deeper water prove that these so-called fish-tanks must have been high and dry in the Roman period. For a description of other instances of submerged houses near the shore, we must refer the reader to our archæological paper, and will only mention the two submerged regions off the villa belonging to the Earl of Rosebery and off the Gaiola.

The former lies just beyond the Capo di Posilipo, and inside the Pietra Salata; it is a tract of sea-bottom of some dozen acres in extent, upon which there are still standing several foundations of buildings within an ancient sea-wall, and protected by concrete piers 17 feet high, the tops of which are some 2 fathoms below the surface.

All round the Gaiola islets, and extending seaward for the best part of a quarter of a mile from the mainland, are submerged shoals which must undoubtedly have been out of the water when the many buildings

standing upon them were erected. We have been able to find traces of artificial work, at a depth of 13 feet, which seems once to have been above water, while artificial piers rise from water of about 4 fathoms. It is quite possible that we have lit upon the forgotten site of the old Greek colony of Parthenope, which became Palæpolis when Neapolis was founded; for the extremity of Posilipo is just such a site as the Greeks would have chosen.

2. *The Forgotten Coast Road.*—Along the greater portion of the Posilipo shore the low cliffs now rise directly from the water. The evidence of the former existence of a road under the cliffs on the edge of the sea is derived partly from the absence, until quite recently, of any proper means of communication between the many ancient buildings which line the shore; partly from the existence of ancient columbaria along the supposed course; and partly from the occurrence of several ancient tunnels or cuttings piercing the more exposed headlands, through which the road is believed to have passed. The floors of two of these ancient tunnels are now some 6 feet under water. Such a coast road would not only have afforded means of communication between the Gaiola (Palæpolis?) and Rosebery regions and Neapolis, but would also explain the purpose of the tunnel of Sejanus through Coroglio, 844 yards in length, and with a larger cross-section than the Grotta Vecchia, a tunnel made to carry all the traffic between Puteoli and Neapolis, in the time of Augustus. We have assured ourselves that no material obstacle to the road exists, always assuming that the land-level was at least some 10 feet higher than at the present day. The ancient coast road, on emerging from the tunnel of Sejanus, would have followed the Vallone di Gaiola to the head of the harbour, and then have skirted the sea, passing in front of the Casa degli Spirit and the other Roman houses on the shore, until it reached the region at the Capo di Posilipo, where, after bending to the north-east, it would finally have reached Neapolis.

3. *The Flooded Quarries.*—Under the precipitous cliffs which skirt the Cala di Trentaremi, are several vast caves, which we believe to have been the ancient quarries whence the Roman masons drew their stone for the many buildings along the shore. According to a rough estimate, some 200,000 cubic feet of stone must have been taken out of the cliffs here. The antiquity of the excavations is proved by the continuation of the upper erosion-line into them. The floors of the Grotta dei Tuoni and delle Palumbe are submerged to a depth of 15 to 20 feet, and the distance through which the land has sunk may be estimated by the depth of these old quarry floors below the surface of the water.

Let us state our reasons for thinking the caves to be artificial rather than of natural origin.

a. The tufa rock in which these caves have been excavated does not, like the limestone of Capri, lend itself to natural cave-formation.

β. Caves, when they are due to erosion by water, are widest at the surface of the water. But the walls of certain of the Trentaremi caves, by sloping outwards under the water, make them somewhat wider below than at the surface.

γ. A passage with walls which have been artificially cut by a tool * leads out of the side of the Grotta dei Tuoni, but, being entirely submerged, it has been impossible to follow it.

FIG. 11.—TUFA CLIFFS, CALA DI TRENTAREMI.

The arrow indicates the upper erosion line.

4. *The Sunken Harbour of Pausilypon.*—Arranged in line and parallel to the shore are the inner artificial barriers of this ancient harbour. Like the defences of other Roman harbours upon this coast, they take the form of isolated square-shaped concrete piers, known as *opus pilarum*.

The tops of the piers are now 2 fathoms below the surface, although they must have been raised considerably above it when they were built. Further out to sea a group of four piers rises from a depth of $3\frac{1}{2}$ fathoms to 2 fathoms below the surface. These and a shoal beyond marked the entrance to the harbour. If we may assume that the concrete piers were carried up to a height of 4 feet above the Roman water-level, the land must have subsided 16 feet at this point.

* Reported to me by a diver.

The utility of a harbour at the southern extremity of Posilipo in Roman times is obvious, for there are very many indications of a numerous and wealthy population.

(To be continued.)

GEOGRAPHICAL DISTRIBUTION OF VEGETATION IN YORKSHIRE.

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PART II.: HARROGATE AND SKIPTON DISTRICT.*

The observations necessary for the present map and survey of the vegetation were made during the same period as those in the Leeds and Halifax district (Part I.). The detailed survey of the western hill region was carried out chiefly by Mr. Rankin. The district lies directly to the north of Part I., the eastern and western boundaries of the two maps being continuous. The western limit lies in the hill mass of Craven, and excludes the Ribble basin on the west of the Pennine watershed. The drainage areas included are those of the Aire, Wharfe, and Nidd, with portions of the Ure and Swale in the North Riding, and part of the Ouse. The north-western part is a plateau, with an altitude from 1500 to 2300 feet (456 to 700 metres), cut up by deep valleys, locally known as dales. Towards the east, the country declines gradually into the Plain of York, which is below 100 feet (30 metres).

The factors which determine the character of the vegetation in this district may be conveniently considered as—

(*a*) Edaphic or Soil Conditions; (*b*) Climatic or Aërial Conditions.

(*a*) *Edaphic Conditions.*—The geology of the area is somewhat complex, and reference to a geological map is advisable. We are indebted to Mr. P. F. Kendall, of Yorkshire College, for the following sketch of the salient features.

"The rocks of the district exhibit the following succession:—

(7) Trias	... ...	Soft red sandstones.
(6) Permian	... ...	Magnesian Limestone, with lenticular beds of marl.
(5) Coal Measures	... ...	Shales, with occasional sandstones.
(4) Millstone Grit	... ...	Thick beds of felspathic grit, with intervening shales.
(3) Yoredale Rocks	... ...	Alternations of limestone, sandstone, and shale.

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* Map, p. 236. Continued from vol. xxi. p. 401.

(2) Carboniferous Limestone	Massive white limestone.
(1) Silurian and older rocks	Chiefly slates and hard grits.

"The Silurian rocks make a small outcrop on the high plateau about Malham Tarn, and are in part responsible for a change in the vegetation perceptible there. This will, however, be best considered in connection with a map to be produced later. The Carboniferous (or Mountain) Limestone is not clearly marked off from the Yoredale series, which is, indeed, a modification of the upper part of the Carboniferous Limestone produced by invasion of sedimentary materials from the northward. The sedimentary rocks (sandstones and shales) form a succession of wedges, whose thin ends are directed southwards. From Malham to Threshfield, in Wharfedale, the Mountain Limestone is abruptly cut off by a great dislocation, the Northern Craven fault, which can be distinguished for a long distance by the sharp contrast between the grassy pastures of the limestone and the dark heather or grass heath vegetation of the Millstone Grit. In the valleys of the Upper Wharfe and its tributaries, as well as in Upper Airedale, the limestones of divisions 2 and 3 (see table above) occupy a large area, and attain altitudes of about 1500 feet. From the main outcrop, tongues extend from Threshfield eastward to Keld Houses, near Pateley bridge, and from Skipton across to the Wharfe near Bolton Abbey.

"The Millstone Grit forms a cap on the hills above 1500 feet in the north-western part of the map, and extends as a continuous sheet over an area roughly defined by Bradley and Lamb Hill on the northern edge of the map, and Thorner towards the south-eastern corner on the southern edge. Small inliers of the Yoredales rise through this rock in Upper Nidderdale and at Harrogate. Three small patches of the Coal Measures appear on the southern margin at Yeadon, Baildon, and Laneshaw. The Millstone Grit declines to the eastward and disappears under the Magnesian Limestone of the Permian series, whose western boundary is indicated approximately by Mickley, Azerley, Fountains Abbey, Markington, Brearton, Bilton, Starbeck, Plompton, Spofforth, East Keswick, Bardsey, and Thorner. The eastern belt is occupied by Trias, but it is deeply covered by Drift and Alluvium, through which it emerges only in a few small patches near Ripon. The glacial deposits are extensively developed, especially in the valleys, and in places are so heavily charged with limestone *débris* as to produce a vegetation characteristic of limestone in a district composed of other rocks."

The area offers an excellent opportunity for contrasting the limestone vegetation with that of neighbouring sedimentary rocks. The task is made easier by what has already been done in or near this district by Mr. J. G. Baker (1885) * and Mr. F. A. Lees (1888). The

* The numbers in brackets after an author's name indicate the year in which a book or paper was published. The titles of the works referred to will be found in the

introduction to "North Yorkshire" as a whole, and the chapter on lithology in particular, deal so thoroughly with the relation of vegetation to soil and climate, that reference should be made to the original itself. Both authors apply to Yorkshire Thurmann's recognition of eugeogenous and dysogeogenous rocks. The former class of rocks yield a plentiful detritus, and the overlying soils are cool and moist. The dysogeogenous rocks—or limestones of this area—yield a less abundant detritus, and are in Yorkshire much fissured and broken, so that the overlying soil is comparatively dry. A map, showing the distribution of the underlying rocks and their constitution, is included in 'The Flora of West Yorkshire.' The value of the work of these authors is supported by the evidence of the present survey, the scale of which allows of considerable detail in representing the distribution of the vegetation. The vegetation of the district and the geology, speaking generally, vary together. The limestones especially may be traced from the plants with considerable accuracy. The effect of surface deposits, whether peat, alluvium, or glacial *débris*, is to mask the true relation of rocks and overlying vegetation. In this district, the deposits are most conspicuous where they cause local displacement of the limestone vegetation by one more like that of the sandstone rocks.

The water-supply is an important edaphic factor. A series of springs emerging from some rock-stratum rarely fails to alter the vegetation. The zone of grass heath round so many of the moors is due in part to the constant moisture and the increased food-supply brought by springs emerging on the slopes. The wet and dry associations of the grass heath and heather moor are also correlated with the water-supply. The conditions of drainage are no less important. Thus, slopes have a vegetation differing from that of a flat, or almost flat, plateau. A prime factor in determining the vegetation of the limestone is the rapid drainage and scanty reserve of water in a soil overlying a much-fissured rock.

(*b*) *Climatic Conditions.*—The variations in climate are considerable for so limited an area, and only the chief features can be indicated now. The following table gives the mean annual rainfall for places within the district. In order to facilitate reference to the map, the river-basin in which the station occurs is given. The number in brackets indicates the number of years of observation, and the rainfalls are given to the nearest inch. The thirty-year observations (1870 to 1899) were kindly supplied by Dr. H. R. Mill. The other records were estimated by us from 'British Rainfall,' generally only for the

List of References at the end of this paper. The authors' names are arranged alphabetically, and the papers of each author in chronological order, with the year-number in brackets. In the case of a periodical, the number in brackets is the year of publication of the paper referred to.

ten years 1891 to 1900, and are therefore only correct for that period. The York record for fifty-four years is taken from a pamphlet issued by Messrs. H. Richardson & Co., York.

MEAN ANNUAL RAINFALL.

Station and number of annual observations.	Altitude.	Rainfall.	Zone of vegetation.
	Feet.	Inches.	
York (average of five gauges) (54) ...	50	24	Wheat cultivation.
South Milford ... ... (30) ...	70	26	
Ripon (Ure) ... ... (10) ...	120	27	
Knaresboro' (Nidd) ... ... (10) ...	200	27	
Leeds (Allerton Hall) (Aire) (30) ...	418	28	
Harewood (Wharfe) ... (10) ...	139	31	
Silsden Reservoir (Aire) ... (10) ...	560	31	Near upper limit of wheat.
Skipton (Aire) ... ... (10) ...	350	34	
Bolton Abbey (Wharfe) ... (6) ...	350	36	
Ilkley (Wharfe) ... ... (10) ...	600	37	
Blubberhouses (Washburn) (10) ...	575	38	Cultivation without wheat.
Pateley Bridge (Nidd) ... (10) ...	410	41	
Dallow Moor (Skell) ... (10) ...	859	36	Heather moor.
Barden Reservoir (Wharfe) (10) ...	746	43	
Grimwith Reservoir (Wharfe) (30) ...	890	46	Near eastern (or drier) edge of Moss moor.
Rainstang (Nidd) ... ... (10) ...	1470	47	
Masham Moor (Ure) ... (10) ...	1412	48	
Angram (Nidd) ... ... (10) ...	1150	55	Moss moor.
East Gill Head (Nidd) ... (9) ...	1710	55	
Malham Tarn (Aire) ... (10) ...	1296	58	Limestone pasture (western rainfall).
Arncliffe (Littondale) (Wharfe) (39) ...	734	61	

The mean annual rainfall is under 30 inches (75 cms.) east of a line drawn from Masham (Swinton) southwards to Ripley (on the Nidd), and then curving slightly westwards between Leeds and Bradford. A roughly parallel line at from 5 to 8 miles west denotes the beginning of rainfalls over 40 inches (100 cms.). In the valleys of the Lower Wharfe and Aire, the zone of rainfalls between 30 and 40 inches is deflected up the valleys for a considerable distance. The relation between the rainfall and the zones of vegetation will be dealt with as the latter come under consideration.

The records of temperature are scanty and not always reliable, hence it is as yet unsafe to make comparisons between this factor and the vegetation. The mean annual temperature of lowland stations in Yorkshire given by Dr. Buchan (1898) shows that they are at least 48° Fahr.; Leeds (137 feet) is about 49° Fahr., York and Wakefield are each about 48° Fahr. In regard to higher stations, there is approximately a decrease of 1° Fahr. for each 300 feet ascent. Thus Harrogate (344 feet) and Bradford (366 feet) are each about 47° Fahr., Aysgarth (658 feet) nearly 46° Fahr., and Hawes (1135 feet) 44° Fahr. The coldest month of the year for Yorkshire stations is January (35° to 38° Fahr.); the warmest month is July (57° to 61° Fahr.).

Other features of the climate of Yorkshire are described in the

introductory chapters in the Floras of Mr. Baker (1885) and Mr. Lees (1888).

The general situation of the farmland, woodland, and moorland in the present area agrees with that shown in the map of the Leeds and Halifax district. The chief mass of farmland and woodland occupies the eastern lowlands and the dales; the moorland is almost all confined to the western highland. The distribution of the vegetation in this district varies largely with the nature of the underlying rocks. It is, therefore, advisable to consider the vegetation of the Mountain Limestone and Permian Limestone apart from that of the Millstone Grit and other sedimentary rocks. The moorland and woodland, as will be seen later, are closely related, and will be kept together. The general plan of the following pages is thus arranged:—

A. The Moorland and Woodland of the Sandstones and Shales.

B. The Moorland and Woodland of the Limestone rocks.

C. The Farmland.

A. Vegetation of the Sandstones and Shales.

1. The Moorland.—In contrast with the moors of the narrow Pennine plateau south of the Aire valley, the moors of the present district are broad and extensive. The country is wilder and more desolate, and, being remote from large centres of population, shows few indications of interference by man. The various forms of moorland vegetation are found on a grander scale, and, whilst showing new features, they serve to check opinions formed in the Leeds and Halifax district.

The Cotton-grass Moss or Moor.—Stretching from the north-west limits of the map beyond Buckden Pike, southwards for 18 miles to Rocking Moor, there is a broad area of cotton-grass moor, broken only by two narrow tongues of limestone pasture near Kettlewell and Dry Gill. The range of elevation is from 1250 feet (380 metres) to 2000 feet (606 metres). Over this extensive and high moorland, the dominance of the two cotton-grasses (*Eriophorum vaginatum* and *E. angustifolium*) is undoubted; and confirms the earlier recognition of these as the dominant plants of the higher Pennine plateau (see Figs. 1 and 4). Crowberry (*Empetrum*) and Bilberry (*Vaccinium Myrtillus*) are frequent, though variable in quantity from place to place. Other associates are such as already detailed in Part I., but in addition, in this less-frequented locality, more records of the rarer plants have been obtained, including *Rubus Chamæmorus*, *Drosera rotundifolia*, *Arctostaphylos Uva-ursi*, and *Lycopodium Selago*. An area such as this, covered almost entirely by cotton-grass, is dreary in the extreme. The peat is rarely less than 5 feet in depth. The rainfall is high and frequent. In the wet season, the moor is a soaking mass, with small pools between

the tufts of cotton-grass, and soft dangerous peat-banks fringing the numerous watercourses (see Fig. 1, Part I.).

Near the margin of the moss the dominance of cotton-grass is frequently shared by Heather (*Calluna*) and Pink Heath (*Erica Tetralix*). This association, indicated by "EH" on the map, is well developed at the head of Nidderdale and Coverdale. The commoner associates are *Empetrum nigrum*, *Vaccinium Myrtillus*, *V. Vitis-Idæa*, and *Rubus Chamæmorus*. The situation is at the moor-edge, on the plateau just above the steeper slopes occupied by the heather moor. The substratum is peat, varying in depth from 5 to 8 feet, and nearly always wet and boggy. *Erica Tetralix* is most abundant where the bog is constantly wet. On the other hand, drier conditions favour *Calluna*. The zone, being found near the lower limits of the cotton-grass moss, may be regarded as transitional between this and the heather moor.

The Vegetation of Summits.—The Bilberry (*Vaccinium Myrtillus*) was found to be the dominant social form on the rocky wind-swept summits of the Pennines described in Part I. The peaks of several of the lower moorlands in the present district were also found to be occupied by the bilberry and a few associates adapted to withstand the drier and more exposed conditions of that situation. The best example is on Earl Seat, a peak of Barden Fell rising to 1474 feet. The corner of the fell rises abruptly from the valley as a dry rocky slope, scantily covered with *Vaccinium Myrtillus*, *V. Vitis-Idæa*, *Calluna*, and occasionally the bracken fern. The Vaccinium summit is more completely occupied by the bilberry, and in one direction changes gradually into cotton-grass moss.

On the summit of Great Whernside, the Vaccinium association is quite absent. This is a long narrow ridge with steep sides, set conspicuously on the general mass of moorland (see Fig. 4). It is surrounded by deep peat with cotton-grass vegetation, which rises to over 2000 feet on the eastern side, but not so high on the steeper western slopes. The summit-ridge from the edge of the peat-bog upwards is rocky, with a scanty soil which supports a meagre vegetation consisting chiefly of grasses. Here and there are patches or islands of peat. The peat is loose in texture and scantily covered with cotton-grass and crowberry, which as peat-binders are largely responsible for the maintenance of the islands. The few plants occurring on the peat islands belong to the cotton-grass moss, but the grassy or alpine pasture is quite distinct. The following plants were recorded:—

Alpine Pasture.	Peat Plants.
* *Nardus stricta*, L.	*Eriophorum angustifolium*, Roth.
Deschampsia flexuosa, Trin.	*E. vaginatum*, L.
Festuca ovina, L.	*Empetrum nigrum*, L.

* The nomenclature of the London Catalogue, 9th edit., is followed throughout.

Alpine Pasture.	Peat Plants.
F. ovina (*f. vivipara*).	*Vaccinium Myrtillus*, L.
Agrostis vulgaris, With.	*Calluna Erica*, DC.
Anthoxanthum odoratum, L.	*Rubus Chamæmorus*, L.
Poa alpina, L.	*Scirpus cæspitosus*, L.
Juncus squarrosus, L.	
Luzula erecta, Desv.	
Carex flacca, Schreb.	
Calluna Erica, DC. Dwarf.	
Rumex Acetosa, L.	
R. Acetosella, L.	
Galium saxatile, L.	
Potentilla silvestris, Neck.	
Cerastium triviale, Link.	
Lycopodium Selago, L.	

The occurrence of the alpine pasture is interesting as indicating a vegetation of a higher zone than the cotton-grass moss. The majority of the species occur in the grass heath of lower elevations, below the cotton-grass, and are absent in the intermediate peaty zone. In the case of Buckden Pike, a few miles further north, the summit is closely carpeted with *Juncus squarrosus* and cotton-grass with associates, including those found on Great Whernside. The type of summit represented by these two peaks is one recognized by Mr. Baker (1885). The association is that of most of the summits over 2000 feet, including Ingleboro, Penyghent, Whernside, and others visited by us to the north and west of this area, and will be further considered in a future paper.

Heather Moor.—A comparison of the present map with that of Part I. will show at a glance the greater development of the heather moor (see Fig. 2). Altitudes above 1250 feet, which in the Halifax district are covered with cotton-grass and thick peat, are in the present area occupied by heather moor or shallower peat. Barden Moor shows this particularly well. This lack of agreement merits closer attention. It was suggested in the previous paper that the chief factors which determined the existence of the Eriophorum moss, as distinguished from the Calluna moor, are (1) a higher rainfall; (2) defective drainage favouring the accumulation of water and the development of thick peat; (3) less interference by man. The present district offers an opportunity for examining these conditions, and at the same time obtaining information on the œcological features of the heather moor.

Rainfall.—Reliable statistics for the moors are somewhat limited, but from those already given (see p. 152; also Part I.) it will be seen that the larger expanses of heather vegetation occur on that part of the moorland which has the lower annual rainfall, whereas the moss moor receives more rain. Dallow Moor and Barden Reservoir are stations on the heather moor, and they show 36 and 43 inches respectively. Other stations which are near heather moors are Ilkley, with 37 inches, and Blubberhouses, with 38 inches. Comparing these with stations

on the moss moor, it will be seen that a lower rainfall prevails on the heather moor.

Drainage.—The better drainage of the heather moor is apparent; as a rule it occupies well-marked slopes, excavated in many parts by streams. The peat is shallow, varying from a few inches to 4 or 5 feet. Continuous tracts of deep wet peat are rare. At the base of the peat there is frequently a distinct "moor-pan," consisting of sand or grit massed with oxides of iron and humus into a hard, impervious stratum of dark-brown sandstone. Graebner has recently (1901) indicated the widespread occurrence of this pan in the heaths of North Germany, and the method of its formation. Our observations amply confirm his, though it is not uncommon to find the moor-pan replaced by a layer of yellowish-white clay of close texture.

Influence of Man.—The heather moors are chiefly preserved as grouse-shootings, and in a less degree as sheep-walks. The moors on which ling (*Calluna*) is most dominant are regularly burnt in patches of a few acres by the keepers, for the purpose of maintaining a vigorous growth of young heather. Where the heather is slow in recovering on a burnt patch, *Vaccinium Myrtillus* and *V. Vitis-Idæus* may temporarily secure dominance. Near the upper limits of the heather moor, as on Rocking Moor, man has obtained large tracts from the cotton-grass moors, and there fostered heather. The process seems to have been—grazing the cotton-grass heavily by sheep, burning, deep drainage, and clearing away peat.

The vegetation of the heather moor is uniform over considerable areas (Fig. 1). The ling is knee-deep when growing luxuriantly, and the close growth allows but few associates.

The following are typical species:—

Dominant.	Common Associates.
Calluna Erica, D.C.	*Potentilla silvestris*, Neck.
Sub-dominant.	*Galium saxatile*, L.
Vaccinium Myrtillus, L.	*Erica cinerea*, L.
V. Vitis-idæus, L.	*Rumex Acetosella*, L.
Erica Tetralix, L.	*Luzula erecta*, Desv.
Juncus, spp.	*Scirpus cæspitosus*, L.
Nardus stricta, L.	*Agrostis vulgaris*, With.
Deschampsia flexuosa, Trin.	*Molinia varia*, Schrank.
Pteris aquilina, L.	*Lomaria Spicant*, Desv.

The sub-dominant species are noteworthy, because under suitable conditions they become more or less dominant, and, competing with Calluna, they disturb the uniform tone of the heather moor. The conditions which favour each are somewhat different. The bilberry is present throughout every heather moor, but along the moor-edge escarpments, and on the drier summits, it increases so as to become a conspicuous dominant form. The cowberry (*Vaccinium Vitis-idæus*)

accompanies the bilberry, attaining its maximum development on dry rocky ground. The bracken (*Pteris*) is often found growing luxuriantly, breast-high, on the steep slopes of a stream ravine. The rocky fell-sides are similarly frequently covered with this fern. Occasionally it grows so free from admixture with other plants, that areas, often acres in extent, are annually mown by freeholders of the townships for use as cattle-bedding. The moor mat-grass (*Nardus stricta*) may become so conspicuous that its intrusion is visible a long distance away. Occa sionally, where little attention is paid to the heather by the keepers, the mat-grass seems to be struggling successfully with it and to choke it out.

The taller rushes (*Juncus*) form close associations or Junceta, and are a prominent feature of a heather moor. The habitat is the marshy hollows or flats, the first gathering grounds of the moor streams. Many of the larger Juncus marshes are indicated on the Ordnance Survey maps, though too small for representation on our map. Good examples occur near the Woolstones on Denton Moor, and on Dallow Moor. Small examples are to be found where springs emerge. The dwarf shrubby vegetation of the drier heather moor is so little present in these Junceta that they are mown by scythe or sickle. The close growth of the tall rushes is exclusive of other plants, but on the ground beneath and around the margins the following occur :—

Juncus effusus, L.
J. conglomeratus, L.
J. supinus, Moench.
J. lampocarpus, Ehrh.
J. acutiflorus, Ehrh.

Ranunculus Lenormandi, F. Schultz.
R. Flammula, L.
Stellaria uliginosa, Murr.
Montia fontana, L.
Potentilla palustris, Scop.
Drosera rotundifolia, L.
Hydrocotyle vulgaris, L.
Galium palustre, L.
Cnicus palustris, Willd.
Schollera Oxycoccus, Roth.

Andromeda Polifolia, L.
Erica Tetralix, L.
Veronica scutellata, L. (uncommon).
Pedicularis palustris, L.
Pinguicula vulgaris, L.
Narthecium Ossifragum, Huds.
Juncus squarrosus, L.
Potamogeton polygonifolius, Pour.
Scirpus cæspitosus, L.
Carex pulicaris, L.
C. curta, Good.
C. echinata, Muss.
C. Goodenowii, J. Gay.
Molinia varia, Schrank.
Nardus stricta, L.
Sphagnum, spp.

Around pools of standing water on the moor, the dominant forms are frequently *Juncus squarrosus* and *Erica Tetralix*, while the taller rushes are much less conspicuous. Such places are also favourable to many of the above plants.

Cotton-grass also occurs locally on wet parts of the heather moor. In some cases the cotton-grass bog may lie at a lower level than the heather moor, and thus apparently contradict the view previously expressed, that the cotton-grass moss occupies the upper zone of a moorland, and heather the lower. Where the moss is developed at a lower

level, it is in some badly drained trough. Cases occur on Rumbolds Moor and Barden Moor.

Grass Heath (H Pa).—The grass vegetation in which there is an admixture of the heather moor associates is distinguished on the maps from the natural pasture, or grass without the heath plants (Pa). The former, or grass heath, occurs on poor soils; the latter is very characteristic of the limestone, and is regarded as part of that vegetation. The grass heath generally replaces the heather at the moor-edge, and forms a fringe round the moorland (Fig. 2). It may occur as a close turf of grasses and other plants, on the steep, well-drained slopes, where peat is not formed, and the soil conditions favour a vegetation adapted to a dry situation. On the other hand, the presence of certain grasses may indicate a place kept constantly moist. The constitution of these two extremes of the grass heath has already been given in detail in Part I. The dry grass heath is dominated by the grasses—*Deschampsia flexuosa*, *Festuca ovina*, and *Nardus stricta*, with their associates. The wet grass heath has frequently *Molinia varia* as the dominant grass, with sedges, rushes, and other moisture-loving moorland plants as associates. The presence of a grass heath is thus determined in some measure by natural causes, but enclosure and grazing are responsible for its existence in many places. The extensive tract of grass heath east of the Washburn valley is worth a detailed consideration. Almost all this area has at some time been enclosed as farmland or grazing-ground. Before enclosure it was probably a heather moor with a broad margin of grass heath. The map shows it at the present day with many fields and farms abandoned and reverting to moorland. The soil is poor, the farms small and not very productive, but the abandonment has been hastened because much of the area has been thrown out of cultivation as a result of purchase by the corporation of Leeds as a gathering-ground for a water-supply. Ling and gorse (*Ulex*) are typical of the vegetation which intrudes on the fields left uncultivated or ungrazed. After a few years, some fields are invaded by patches of ling, bilberry, rushes, and other plants of the heather moor. In other fields gorse becomes established along with birch and hawthorn. Where the soil is naturally peaty, Calluna with its associates takes possession at once. Gorse is the intruder when the grass vegetation remains, or when Calluna comes slowly. It was noted in several places that after the gorse had grown tall and thin, Calluna had become established beneath it. A later stage is presented by places where the heather vegetation occupies the moor, except on the knolls and rocky edges where gorse still holds on.

2. Woodland of the Sandstones and Shales.—Wherever the soil is formed of weathered sandstones or shales, the woods are those in which oak is the most common deciduous tree, and Scots pine the most frequent of the conifers. In contrast, the woods of the scars and valleys of the Mountain Limestone are characterized by ash and hazel, while

* Fig. 1. From Bolton Park, looking towards crags of Simon Seat. Pine-wood, and meadow-land at Agill House (800 to 900 feet), intaken from surrounding heather moor. The heather extends upwards to 1,250 feet; the light patches are portions which have been burnt. Cotton-grass moss on the sky-line, above 1,250 feet.

Fig. 2. From Bolton Park looking south-east. Corner of upland oak wood (about 800 feet). The moorland is grass heath, which on the further slopes is strongly mixed with heather. The farm is named "Intake" on the map.

* The Photographs reproduced (except Fig. 3) were generously placed at our disposal by Miss Brownsworth, Photographer, Skipton. Figures 1 and 2 were specially taken for this paper.

the Permian may also claim the beech as a dominant element. On the lowland and in the sandstone parts of the dales of this district, the succession of oak woods agrees generally with that already described in the area south of this (Part I.). Pine woods are, however, more numerous and merit notice.

The following woods are recognized on the Sandstone area:

(1) Gill woods.

(2) Upland oak woods.

(3) Lowland oak woods.

(4) Pine woods.

These types of woodland may be conveniently observed near each other in the extensive woods in Wharfedale near Bolton Abbey. About the Abbey itself, the Wharfe has eroded the sandstones and shales of the Yoredale series, forming a valley with alluvial terraces in the bottom. These are occupied by mixed deciduous trees, including beech and other lowland species, many doubtless planted round this old abbey. The ground vegetation is varied, and includes many plants which prefer shade and moisture. It is a lowland oak wood, modified by the presence of introduced trees. Within the range of the river-floods, it is not unusual to find plants of the Mountain Limestone vegetation washed down from Upper Wharfedale; amongst these may be noted *Geranium lucidum*, *Saxifraga tridactylites*, *Cochlearia alpina*, *Primula farinosa*, *Melica nutans*, and *Sesleria cærulea*. The valley higher up the river is a narrow gorge cut through the Millstone Grits. On the steep rocky banks about the Strid, the oak becomes more abundant, the ground is less shaded, and moorland plants like bilberry, bracken, and even heather, take the place of shade plants. Leaving the river, and passing upwards on the left bank, the same characteristic vegetation—that of the upland oak wood of Yorkshire—will be found to prevail throughout the upper parts of the wood and the tributary valleys. Still higher up these tributaries, near the moor edge, the gill wood is found as a scattered copse of birch and thorn. Plantations of Scots pine and larch, with other conifers, have replaced the gill wood in places, and have been carried on to the moor round the slopes of Simon Seat and Earl Seat, beyond an altitude of 1000 feet (see Fig. 1).

Gill Wood.—The steep descent from the moor plateau, known as a clough in the district described in our former paper, is in this area called a "gill." Many of the gills, especially those of Upper Wharfedale, are eroded from the Mountain Limestone; their vegetation will be dealt with later. Gills excavated from sandstones or shales occur in the course of streams flowing into Wharfedale, from Burnsall down to Otley, and on the tributaries of the Nidd. The dominant plants form a loose scrub consisting of birch, mountain ash, holly, hawthorn, blackthorn, and willows. The undergrowth is, in part, intruding plants from the moor, such as ling and other heaths, bilberry, bracken, and the

moor grasses. The vegetation of the clough, given in detail in Part I., may be found where the conditions are similar, that is, when the stream descends abruptly from the moor. But, as already indicated, much of the moorland is of the drier heather type, and in gills there, the undergrowth is limited, lacking especially those plants which require moisture; the trees are widely scattered, and the undergrowth is that of the open banks of a moorland stream.

The gill wood of this district is interesting, because there is evidence that its distribution at the present time falls far short of what it was formerly. A series of observations in "Studies of Nidderdale" (J. Lucas, 1881) has been particularly useful in completing our notes. The author concludes that the moors of Nidderdale were formerly covered by an ancient forest, which consisted chiefly of birch. He recognizes an upland oak forest, the upper limits of which are about 1200 feet, and above this a birch forest. This evidence is valuable because it indicates the presence in Yorkshire of the sub-alpine birch forest, recognized as the uppermost zone of woodland in the valleys of the Grampians in Perthshire and Forfarshire (R. Smith, 1900). That the clough wood was a modification of the Scottish birch wood, was suggested in Part I., but sufficient evidence was not available to confirm it. Mr. Lucas gives Birk Gill (600 to 900 feet), on a tributary of the Burn (just beyond the northern boundary of our map), as the most typical existing example of the birch wood in this district. Other examples, mentioned by this author, were noted by us before seeing his book. Arna Gill (800 to 1000 feet), on a stream from Ilton Moor into the Pott Beck, shows a birch wood of the gill type, which includes one or two oaks, ash, thorn, and bird cherry. A copse of birch, alder, and willow is to be found near Pry House on the right bank of the Upper Nidd, at an altitude of 1100 to 1200 feet. The existence of the birch wood at higher altitudes is shown chiefly by the occurrence of buried trees in the peat. The details given by Mr. Lucas are here briefly summarized:—

(*a*) Moors east of Great Whernside, *i.e.* Black, Riggs, and Stone Moors. Birch thicket up to 1250 feet. In the peat, birch stems up to 1725 feet, oak stems 1000 to 1050 feet, and hazel nuts at 1650 feet.

(*b*) Woogill or North Moor, north of the Nidd. Thicket with birch up to 1275 feet; isolated mountain ash at 1550 feet; and hazel 1350 feet. In the gills of Steel House Moor, north of Woogill (and beyond the map): thicket in Birk Gill up to 900 feet; isolated trees of birch and mountain ash to 1175 feet, and thorn to 1100 feet; in the peat, birch stems at 1600 feet.

(*c*) Fountains Earth and Dallow Gill Moors. Thicket with birch, thorn, and mountain ash (also isolated trees of these), with holly, alder, and oak, from 800 to 1100 feet; in the peat, birch stems up to 1525 feet. Juniper occurs at 925 feet in one place.

These facts so far confirm the suggestion of Mr. Lucas, that a continuous thicket of birch and its associates covered the present moorland edge, and attained an altitude much beyond the upper limits of any of the existing woods.

Upland Oak Wood.—This zone, already recognized in Part I., is well represented in the sandstone valleys of this area, but is absent in the numerous valleys on the Mountain Limestone. The lower limits of the upland zone is about 500 feet (152 metres). The upper limit occurs when the oak ceases to be a dominant tree—that is, from 800 to 900 feet (see Fig. 2). Isolated living oaks are recorded by Mr. Lucas up to 1100 feet, and dead stems occur in the peat up to 1250 feet. The upland zone of oak is best represented in the gently sloping valleys of the Skell, Laver, and other streams draining the eastern side of the heather moor. It is less extensive in the short, steep, lateral valleys of the Wharfe and Nidd. The dry, upland, rocky wood is favourable for the growth of Scots pine and other conifers; and in this area, where many of the woods are systematically tended, there is a considerable admixture of these trees in the oak wood, and this is shown on the map. In many cases the original woods have been completely replaced by pine wood. The effect of the conifers is to alter the characteristic vegetation of the upland oak wood, and in an extreme case the ground may be almost bare. The plants of the upland oak wood are given in detail in Part I., and need not be repeated here. The subdominant species are generally birch, wych elm, holly, hazel, mountain ash, blackthorn, and hawthorn. Sycamore may be introduced from seeds, or planted; beech is also sometimes planted. The chief distinction between the upland oak wood and the birch thicket is the dominance of oak, and the more varied ground vegetation resulting from moister and more sheltered conditions.

Lowland Oak Wood.—Woods of this type occur below an altitude of about 500 feet. In the district already described (Part I.), the oak wood formed a broad zone on the lowlands of the Coal Measures. In this district, however, the lowland oak wood is almost confined to the broad valleys of the larger rivers before these enter the Permian tract. In Wharfedale they extend from Harewood upwards to Burnsall, where they cease on the Mountain Limestone. In Nidderdale, the woods in the valley bottom round Pateley Bridge and down the valley to Ripley are also of this type. The oak (*Quercus Robur*, vars. *pedunculata* and *sessiliflora*) is distinctly the prevailing tree. Sycamore (*Acer Pseudoplatanus*) and wych elm (*Ulmus montana*) frequently share dominance. Beech grows well where planted, and if abundant has a marked effect on the dependent vegetation. It is, however, considered as an introduction into the oak wood, although where beech or other lowland trees are strongly represented in a wood, it is indicated as mixed deciduous. Alder and willows are abundant along the streams. Ash is not

uncommon. Poplars and horse-chestnut (*Æsculus*) are more abundant than sweet-chestnut (*Castanea*) and lime (*Tilia*). Conifers have been planted amongst the deciduous trees in many woods, but pure pine woods are less frequent than in the upland oak zone.

The distinction between the vegetation of the upland and the lowland oak wood was shown by lists of associates in Part I. The outstanding features are summarized thus: The upland oak wood is usually dry and rocky, and deficient in humus; the lowland oak wood is damp, shaly, and richer in humus. The shade cast by the trees is much greater in the latter than in the former. Hence the flora of the latter is much richer in species, especially of the bulbous and early flowering kinds: the flora of the upland oak wood contains a high proportion of late-flowering, moorland xerophytes, which are practically absent from the lowland oak wood. This difference is also observable in regard to mosses and liverworts.

Trias Oak Wood.—On the Permian tract the woods lose the distinctive features of the lowland oak wood, and are dealt with as part of the limestone vegetation. East of the narrow Permian tract, the oak again becomes a conspicuous tree in the woods. The underlying rocks belong to the Trias formation, but the soil is generally derived from the glacial and alluvial deposits, which are here so prevalent. Woods of oak and mixed Scots pine are a characteristic feature, and, with plantations of conifers, form the coverts of this well-known hunting area. The Trias extends eastwards of the present map, and, until the remainder has been surveyed, it is advisable to defer consideration of it.

Pine Woods.—In contrast with the Leeds and Halifax district, the present area shows numerous woods of Scots pine and other coniferous trees from Wharfedale northwards. These woods begin near the moor edge, sometimes on the heather moor itself (see Fig. 1), and may be frequently met with as pure plantations. On the limestone the conifers are not much in evidence, and a well-grown plantation in that area generally indicates glacial or alluvial *débris*. On the Trias, conifers again become a conspicuous element in the woods.

The Scots pine (*Pinus sylvestris*), the only native species, is the one most frequently seen, but larch is often planted in mixture with it. Spruce is not uncommon. Other species occur occasionally in the plantations, but as a rule they are confined to the parklands. The pine wood is best represented in the following habitats:—

(*a*) The heather moor with a well-drained peaty soil; never on the cotton-grass moss.

(*b*) Dry rocky places, such as occur on the moor edge escarpments, or along the rocky banks of a stream ravine.

(*c*) Sandy plains where some peat accumulates; this is the habitat of the Trias pine woods.

FIG. 3. Undergrowth of a Pine wood.
From photograph by Mr. W. B. Crump, M.A. (Halifax).

These habitats are almost similar to those given by Robert Smith in the Tay basin (1898), and he also mentions similar ones in Norway. Prof. E. Warming in Denmark, and M. Christ in Switzerland, also recognize these as habitats of Scots pine in their respective parts of Europe.

The relationship between the distribution of pine woods and that of heather moor is now generally admitted. In the present district the largest pine woods are found near the edge of the chief heather moors. Mr. Baker mentions that Hutton Moor, near Ripon, was formerly a tract of sandy heather land; it is now almost entirely cultivated, but it is interesting to note that the numerous small plantations are almost exclusively conifers. This also obtains on heather moors east of York, *e.g.* Strensall Common; and also at Pilmoor (just beyond the north-east corner of the map).

The occurrence of pine woods on or near the present heather moors suggests that they may represent a zone of natural forest at an altitude above the upland oak wood. In Scotland this is proved not only by the occurrence of living Scots pine at altitudes up to 2000 feet and over in Perthshire and Aberdeenshire, but also by the presence of pine stems in peat up to the same altitude. There is also much evidence that heather moor in the North German Plain (Graebner, 1901), and in Scotland, represents at the present day what has formerly been pine forest. In regard to Yorkshire, we give the opinion of authors dealing with the district. Mr. Baker (1885, p. 373), in referring to Scots pine, says, "This is a tree of the post-glacial peat-swamps. Whether any of the trees now in existence are the descendants of the aboriginal possessors of the soil may be doubted, and it is quite impossible to decide confidently." Mr. Lees (1888) doubts whether this tree is native anywhere in the West Riding, except in Thorne Waste, a lowland moor (about 20 feet), near Goole. Mr. Lucas (1881) does not refer to Scots pine at all, and he never recognized it in the peat of Nidderdale. Thus, although the Scots pine appears to be in favourable conditions on the heather moors at the present time, there is no evidence that it is indigenous or ever formed a primitive forest within the area of either of our maps. In connection with afforestation of moorlands, it is generally admitted that heather moor may be planted with Scots pine, larch, and other conifers, and it is the opinion of the foresters in charge of the pine woods on the Bolton Abbey and the Masham estates that the heather moors adjacent to the existing plantations could, after some little preparation, be planted with conifers (see Fig. 1). The highest existing woods in this district are those on Earl Seat and Barden Moor, where they rise to 1350 feet, while one small plantation in Upper Nidderdale is somewhat above this altitude.

The vegetation of the pine wood is scanty, and consists of plants from the heather moor and grass heath. Where the canopy is close, the

ground is deeply shaded and covered with fallen needles, which decay slowly, forming a humus which readily dries up. The vegetation in such cases consists almost entirely of patches of mosses (*Polytrichum juniperinum* and *Dicranum scoparium* being common). Near the less-shaded margins of the wood, bracken fern is abundant, along with the plants of the grass heath. The moor origin of the pine woods above Bolton Abbey is easily traced from the ground vegetation. Heather occurs where the ground is peaty, remaining even in the deep shade beneath closely planted young trees. In open dry places and along the rides, a loose sward is formed by grasses from the grass heath, including *Deschampsia flexuosa*, *Agrostis*, *Holcus*, and *Festuca*. Where the drainage is deficient, plants of the wet grass heath or small Juncus swamps occur. Self-sown pines occur in the clearings and on the moor near the woods, but they are not so numerous as self-sown birch or mountain ash.

The vegetation of the pine wood may be regarded generally as that of the neighbouring moorland associations. The species characteristic of old pine woods in Scotland are either rare or absent in this area. *Trientalis europæa*, *Pyrola minor*, *P. media*, and *Listera cordata* are found occasionally on Sawley, Dallowgill, and other moors between the Wharfe and Ure. *Linnæa borealis*, *Corallorhiza innata*, and *Goodyera repens*, the latter especially typical of Scottish pine woods as far south of the Tweed, seem to be entirely absent from this district. These facts appear to support the view that the pine woods are not natural along the edge of the heather moor, but have been established by man.

B. Vegetation of the Limestone Rocks.

The distinctive vegetation of the two widely separated areas of limestone, the Mountain Limestone of Craven, and the narrow lowland tract of Permian Limestone abutting on the plain of York, has added much to the interest of this district. The sharp contrast with the vegetation of the neighbouring non-limestone formations is quickly noticeable even where the limestone outcrop is small and local. The higher altitude and greater rainfall of the Mountain Limestone area produces conditions very different from the lowland and drier Permian tract. The two areas may therefore be discussed separately, although it may be observed here that they have some features of the vegetation in common.

The Mountain Limestone.—The main mass of limestone developed in the north-west of this map is continued northwards into Wensleydale and westward into Ribblesdale and Lonsdale. The chief œcological features of the limestone vegetation may be observed within the limits of this map. Our conclusions, however, are based, not on the survey of this part only, but on what has also been found in neighbouring parts. Upper Wharfedale and Airedale give the best examples of the limestone vegetation. In Nidderdale the limestone comes to the surface only in a

FIG. 4. Great Whernside with Kettlewell. Meadows near the Wharfe in foreground. The natural pasture on limestone extends as far up as the white walls (about 1,500 feet). The dark area above is heather. The upper slopes are cotton-grass moss, and the summit (2,310 feet) is Alpine pasture. (The photograph was taken across the valley, from about 800 feet altitude.)

FIG. 5. Gordale Scar; height nearly 300 feet. The long scree on the right with a thin copse of hazel and birch. On the left, vertical scars with debris and copse vegetation on the ledges; the dark shrubs are yew.

few localities. The range of elevation on Malham Moor (High Mark) is from about 500 feet (150 metres) in the valleys, to 1750 feet (530 metres) on the moor-top; but in Upper Wharfedale, the upper limit may be taken on the average at about 1500 feet (456 metres).

The valleys are narrow, and the farm-land extends along the river as a narrow tract of grazing meadows (see Fig. 4). A few fields distant from the river, steep scars rise sharply up. In places these scars, with the trailing screes at the base, are almost bare, but commonly they are covered with a loose copse, which shelters a grassy vegetation. Above the first line of scars there are pastures, often flat, sometimes steep and rocky, which again give place to higher scars; and so pasture and scar alternate, until the plateau is reached. Deep and rugged gorges have been cut in the hill-sides by torrents. In summer these are dry, or small streams run in them; in a few cases the volume of water is large and constant. Like the scars of the main valley, these gorges are often fringed with a loose copse. The view from some favourable hilltop down into the valley would take in the main features of the vegetation (Fig. 4): precipitous white scars and narrow ravines, white stone walls often running straight for miles, light green pastures, rich in the valleys, but thin in the pastures and slopes of the uplands. Trees are represented by scattered woods in the bottoms, and thin copses fringing the scars. The contrast between this vegetation and the dark green or brown heathery slopes of the Millstone Grit hills can be seen plainly miles away.

Hill Pastures.—Where the Millstone Grit caps the summits of the high ridges, cotton-grass and heather prevail, while the limestone hill pasture occupies the slopes below (see Fig. 4). On the extensive plateau of High Mark (Malham Moor), the limestone rises to the summit (1765 feet). So permeable is the limestone that, except where deposits of boulder clay occur, the moor is dry, although the annual rainfall approaches 60 inches (150 cms.). The few streams that arise either sink into underground channels which come to light again often many miles away, or cut for themselves deep narrow gills. An example of the former case is the stream from Malham Tarn, which, as soon as it leaves the Silurian slates, sinks into the limestone to reappear nearly 3 miles away. An example of the latter is Gordale (Fig. 5). The monotony of the wide expanse of pasture is relieved only by the bare white scars and pavements and the long lines of limestone walls. The moor is practically treeless. On the edge of the scars, a few struggling mountain ashes, thorns, and yews have established themselves in the clefts of the weathered rocks. Small groups of sycamore and ash indicate some upland farm, or a sheltered position on the lee side of some hill. For many years Mr. W. Morrison has endeavoured to afforest the grounds round his residence at Malham Tarn (1300 feet, and off the map almost west from Middle House on the western edge). A million trees have

been planted, and of these scarcely fifty thousand survive. The owner's experience is that the locality is unsuited for larch and Scots pine, and that sycamore, beech, birch, alder, thorn, wych elm, and mountain ash grow, but exceedingly slowly.

Craven has from time immemorial been famous for its sheep-walks. Though the soil above limestone is somewhat thin, the short, crisp grass forms good pasturage, consisting chiefly of sheep's fescue (*Festuca ovina*). In early summer the yellow mountain pansy and wild thyme are present in profusion. The following plants occur generally on the dry hill pasture of the limestone:—

LIMESTONE HILL PASTURES.

Ranunculus bulbosus, L.
Thlaspi occitanum (Jord.).
Viola lutea, Huds.
Polygala vulgaris, L.
Arenaria verna, L.
Linum catharticum, L.
Geranium sylvaticum, L.
Anthyllis Vulneraria, L.
Lotus corniculatus, L.
Poterium Sanguisorba, L.
P. officinale, Hook.
Saxifraga granulata, L.
S. hypnoides, L.
Galium verum, L.
Scabiosa Columbaria, L.
Antennaria dioica, R. Br.
Carlina vulgaris, L.
Carduus nutans, L.
Cnicus eriophorus, Roth.
Primula veris, L.
Gentiana Amarella, L.
Thymus Serpyllum, Fr.
Stachys Betonica, Benth.
Plantago media, L.
Rumex Acetosella, L.
Habenaria conopsæ, Benth.
H. albida, R. Br. Rare.
H. viridis, R. Br.
H. bifolia, R. Br. Rare.
H. chloroleuca, Ridley.
Luzula campestris, DC.
Anthoxanthum odoratum, L.
Avena pubescens, Huds.
A. pratensis, L.
Sesleria cærulea, Ard.
Cynosurus cristatus, L.
Kœleria cristata, Pers.
Briza media, L.
Festuca ovina, L.
Ophioglossum vulgatum, L.
Botrychium Lunaria, Sw.

In moist places where springs arise, or by the sides of streams, the following may be found:—

Trollius europæus, L.
Cochlearia alpina, Wats.
Parnassia palustris, L.
Valeriana dioica, L.
Primula farinosa, L.
Pedicularis palustris, L.
Orchis latifolia, L.
O. maculata, L.
Juncus compressus, Jacq. Rare.
Scirpus Caricis, Retz.
Carex dioica, L.
C. flava, L.
C. hirta, L.
Glyceria fluitans, R. Br.
Selaginella selaginoides, Gray. Uncommon.

On this same moor-plateau there are numerous troughs in which boulder clay has lodged, and here the vegetation assumes more or less the character of a heath. On the summit of High Mark, the cap of Millstone Grit, so frequent on neighbouring summits, is absent, and any glacial *débris* which may have been present is reduced to patches. The bilberry (*Vaccinium Myrtillus*) and the heath-moss (*Polytrichum*) may

be found along with plants of the limestone pasture. On the shoulder overlooking Cowside Beck, within a single square yard may be found *Sesleria cærulea*, *Festuca ovina*, *Viola lutea*, *Thymus Serpyllum*, *Vaccinium Myrtillus*, *Calluna Erica*, *Nardus stricta* and *Polytrichum*; representatives of the limestone hill pasture and the heath growing in mixture. This place is over a mile distant from the nearest heather moor, from which it is separated by a deep limestone gill. Again, on the steep slopes from Hawkswick Moor into Littondale there are, below the scars of limestone and covering the screes, large tracts of heather co-extensive with those on the grit cap above. The ling has been found here and elsewhere growing from clefts in limestone sink-holes, with its roots frequently closely pressed against the rock itself. On the flat spurs of Ingleboro, a little west of the present area, large tracts of limestone pavement bear a heather vegetation, which includes many plants of the heather moor. In face of these facts, it cannot be overlooked that heather may, under certain conditions, establish itself on limestone, but a fuller discussion is reserved for a future paper.

Limestone Pavements.—The pavements or flat summits of exposed limestone, bare of soil and weathered into a maze of narrow and deep clefts, form a striking feature of the Mountain Limestone. They occur generally on the exposed summit of a limestone scar, but others, isolated in the midst of hill pasture, are the remains of some weathered rocky ridge. At first sight apparently barren, except for an occasional dwarfed shrub emerging from a cleft, the pavements on closer examination reveal an interesting flora. The conditions of plant-life in the pavement clefts are very distinct from the adjoining hill pasture. There is shelter from the rigours of wind and sun, excessive evaporation during the heat of summer is checked, moisture is retained by a soil of considerable depth lodged in the numerous crannies, and throughout the year the shade is such as to favour shade-loving plants. Many of the plants found are those of the valley woods. In passing upwards from the moist valley woods, the plants abundant there are either absent or rare in the open pastures and the loose open scar woods, but reappear in the pavements above the scars, at an altitude seldom lower than 1000 feet (300 metres). The commonest plants are wood sorrel, wood garlic, anemone, hart's-tongue fern, and the green spleenwort. The following is a more complete list:—

Thalictrum calcareum (Jord.).
Anemone nemorosa, L.
Actæa spicata, L.
Viola Riviniana, Reich.
Geranium Robertianum, L.
Oxalis Acetosella, L.
Rubus Idæus, L.
Cratægus Oxyacantha, L. Dwarf.
Ribes petræum (Sm.). Rare.
Circæa lutetiana, L.
Heracleum Spondylium, L. Dwarf.
Hedera Helix, L.
Lactuca Muralis, Fr.
Corylus Avellana, L. Dwarf.
Listera ovata, R. Br.
Allium ursinum, L.
Asplenium viride, Huds.
A. Trichomanes, L.
Scolopendrium vulgare, Symons.
Polystichum lobatum, Presl.
Lastræa rigida, Presl.

The Limestone Scars.—The scars are either walled off from the adjoining hill pasture, or they are in themselves so precipitous that even goats seldom invade them. An opportunity is therefore given for the development of a natural vegetation, quite distinct from that of the grazing grounds. The precipitous scar-face, however, offers conditions very different from the scree of weathered *débris* at its base. At Malham, Gordale (Fig. 5), and Kilnsey, the scar-faces are almost vertical for nearly 300 feet, yet the numerous joints and crevices of the weathered limestone shelter a varied flora, consisting chiefly of compact dwarf plants, with at the most a few stunted trees. The screes are more favourable to vegetation, and where, as is often the case, the scars consist of a series of broad ledges littered with *débris*, the vegetation assumes the form of a shrubby thicket, with hazel and other shrubs dominant. The vegetation of the scar itself must, therefore, be distinguished from the scar wood.

Vegetation of the Scars.—In clefts of the rock and on occasional ledges on the scar, a scanty soil is formed. Such plants as can establish themselves are exposed to the direct rays of the sun, and those reflected from the rock. The amount of water available is scanty. In the deep narrow valleys the winds go up and down the trough. The scars do not, therefore, receive the full blast in front, and plants in the crevices, sheltered by the inequalities of the rock face, do not experience that rush of wind felt on the meadows below, or the upland pastures of the hilltop. The trees on the scars are few and stunted, such as hazel, yew, hawthorn, and mountain ash. The following plants are found here and there amongst the scars:—

Thalictrum calcareum (Jord.).
Arabis hirsuta, Scop.
Draba muralis, L.
D. incana, L.
Erophila vulgaris, DC.
Thlaspi occitanum (Jord.).
Hutchinsia petræa, R. Br. Local.
Helianthemum Chamæcistus, Mill.
Arenaria verna, L.
Geranium sanguineum, L.
G. lucidum, L.
Hippocrepis comosa, L.
Spiræa Filipendula, L. Rare.
Dryas octopetala, L. Local.
Potentilla rubens, Vill. Rare.
Cratægus Oxyacantha, L.
Pyrus Aucuparia, Ehrh.
Saxifraga tridactylites, L.
Ribes petræum (Sm.). Rare.
Sedum Telephium, L.
Galium sylvestre, Poll.
Hieracium Pilosella, L.
H. anglicum, Fr. Rare.
H. cæsium, Fr.
Lactuca muralis, Fresen.
Corylus Avellana, L.
Taxus baccata, L.
Sesleria cærulea, Ard.
Festuca ovina, L.
Asplenium viride, Huds.
A. Trichomanes, L.
A. Ruta-muraria, L
Cystopteris fragilis, Bernh.
Phegopteris calcarea, Fee.

Scar Woods.—These are a characteristic feature of the limestone dales, and are especially well developed round Kettlewell (Fig. 6) and Arncliffe. The lower scars are more favourable than the upper, but occasional examples occur on the higher scars and even on a limestone pavement on the plateau. The hazel is the dominant element most

FIG. 6. Limestone scars and scar-wood at Kettlewell.

FIG. 7. The Wharfe at Grassington Bridge. Grass Woods in the background.

commonly found; but the ash occurs frequently, and sometimes close enough to reduce the hazel to a sub-dominant form. The scar wood is the highest zone of tree vegetation in the limestone area, and takes here the place of the birch zone of the Millstone Grit. Its occurrence on the map is indicated by the letter "A" over the wood colour. The number of ash trees present determines whether the hazel is to be a dominant or a sub-dominant form. As a rule the ash occurs but sparingly, because, being almost the only timber tree in the limestone dales, it is generally removed. In this district few of the woods receive any attention, and little is done to check disforesting. Almost all the scar woods are therefore to be regarded as shrubby thickets, under which the ground vegetation is only slightly shaded, but fairly well sheltered. Hazel, ash, mountain ash, hawthorn, and holly are the chief plants of the thicket. Sycamore occurs, but is not abundant. The ground vegetation is rich and varied. It is in this association that the almost extinct Lady's Slipper orchid occurs. The following plants are representative:—

TREES AND SHRUBS.

Corylus Avellana, L. Dominant.
Fraxinus excelsior, L.
Acer Pseudo-platanus, L. Not abundant.
Prunus spinosa, L.
P. Padus, L.
Pyrus Aucuparia, Ehrh.
Cratægus Oxyacantha, L.
Ilex Aquifolium, L.
Rhamnus catharticus, L.
Rosa, spp.
Rubus idæus, L.
R. fruticosus (agg.).
R. saxatilis, L.
Cornus sanguinea, L. Local.
Sambucus nigra, L.
Viburnum Lantana, L.
Ligustrum vulgare, L.

GROUND VEGETATION.

Thalictrum collinum, Wallr.
Aquilegia vulgaris, L.
Actæa spicata, L.
Cardamine impatiens, L. Local.
Helianthemum Chamæcistus, Mill.
Viola odorata, L.
V. hirta, L.
V. Riviniana, Reich.
Hypericum hirsutum, L.
H. montanum, L. Local.
Geranium sanguineum, L.
G. sylvaticum, L.
G. Robertianum, L.
Spiræa Ulmaria, L.
S. Filipendula, L.
Saxifraga umbrosa, L. Rare.
S. hypnoides, L.
Sanicula europæa, L.
Galium boreale, L. Rare.
G. Cruciata, Scop.
Asperula odorata, L.
Cnicus heterophyllus, Willd.
Centaurea Scabiosa, L.
Lactuca muralis, Fresen.
Primula acaulis, L.
Primula acaulis X *veris*.
Polemonium cæruleum, L.
Lathræa Squamaria, L.
Origanum vulgare, L.
Teucrium Scorodonia, L.
Ajuga reptans, L.
Mercurialis perennis, L.
Listera ovata, R. Br.
Epipactis latifolia, All.
Orchis mascula, L.
Ophrys apifera, Huds.
Habenaria chloroleuca, Ridley.
Cypripedium Calceolus, L. Very rare.
Polygonatum officinale, All.
Convallaria majalis, L.
Allium Scorodoprasum, L.
Scilla festalis, Salisb.
Paris quadrifolia, L.
Luzula vernalis, DC.
Carex pallescens, L.
Sesleria cærulea, Ard.
Melica nutans, L.
M. uniflora, Retz.
Avena pratensis, L.
Polystichum lobatum, Presl.

Woodland of the Limestones.

The limestone scar wood has already introduced some of the features of these woods. The woods of the Mountain Limestone and the Permian are so distinct that they cannot be included in either of the forms of oak wood already described on the non-limestone area. The oak is not abundant enough to merit recognition as the dominant element Pine woods are also by no means abundant on the limestone. The characteristic trees are ash and beech, the former on the Mountain and Permian limestones, the latter on the Permian only.

The ash occurs in the lowland oak woods, but its increase on the limestone is very marked. An opportunity for testing this opinion occurred in an excursion (May 18, 1901) in Upper Airedale: the trees were in foliage except the ash, which in its leafless condition was distinguishable from a long distance, and its abundance was convincing. The Rev. Mr. Shuffrey, of Arncliffe (1891), states that in Littondale, a limestone valley about 8 miles long, there are only seven or eight oaks. The ash is equally characteristic of the Permian tract, and on passing to it from neighbouring formations we have repeatedly observed a distinct increase in the proportion of ash trees in the hedgerows. It is also a conspicuous element of the Permian woods. The ash is generally recognized in forestry as a tree suited to limestone soils, and in Yorkshire this is amply confirmed. We have been told by the forester on the Duke of Devonshire's Bolton Abbey estate, that the ash of Grass Woods on the limestone is much superior to that in the sandstone woods.

The hazel is the forerunner and associate of the ash on the limestone. It is by no means uncommon on the sandstone areas, but its preponderance on the limestone soils makes it an important element. The dry nature of these soils is favourable to hazel and unfavourable to birch. The hazel copse is recognized in plant geography as a stage in the formation of forest, and as a rejuvenator of wood clearings. This is evidently the case in the scar woods already described. The hazel copse is in some cases the transition stage between the treeless scar *débris* and the forest condition; in other cases it is the evidence of disforestation of the ash. On the Permian tract the prevalence of hazel in many of the uncultivated places and disused quarries is similarly explained.

The following types of wood on the limestone have been observed:—

(1) The scar woods of the mountain limestone;

(2) The lowland woods;

(3) The hazel copse of the Permian tract.

Lowland Woods.—These occur on the Permian tract and in the bottoms of the Mountain Limestone dales. In Grass Woods near Grassington (Fig. 7) the transition from a scar wood to the lowland

limestone wood is to be found. Bastow or High Grass Wood occupies the lower series of limestone scars, and is considered to be a scar wood altered by planting. Another extensive scar wood occurs on the opposite bank of the Wharfe, and it presents all the characters of the scar wood of Upper Wharfedale and Littondale. No scar woods occur lower down the Wharfe. The lower part of Grass Wood descends to the alluvial river terraces, which are here broad and mostly under cultivation. Beech, oak, sycamore, and other deciduous trees have been planted with a considerable admixture of Scots pine, larch, and other conifers. The character of the wood is altered, and the ground vegetation includes many plants which prefer more moisture and shade than is available in the upper scar wood. Amongst the associates, however, there are plants of the limestone, which become less frequent in the woods on the sandstone rocks. The latter occur on the Wharfe from Burnsall downwards, and have the characters already referred to in Bolton Woods.

The rich soils of the Permian, in conjunction with the favourable climatic conditions of a lowland district with a low rainfall, are suited to the growth of almost all trees. The woods are therefore varied in constitution, and no greater variety of native and introduced trees occurs in the present district than is found in the Permian woodland. Thus, in Studley Park, on the western edge of the Permian near Ripon, one may find good examples of almost all the woodland trees grown in Britain.

The prevalence of ash has already been emphasized, and although it forms no extensive woods, it is a conspicuous element in all. The beech is undoubtedly very abundant, and wherever a careful examination of the constitution of the Permian woods was made it was always one of the most common trees. The oak is not uncommon, but it is scattered amongst the other trees, and is rarely the dominant element it was in the lowland Coal Measure woods. With such a range of prevalent trees, the conditions offered to the ground vegetation vary from the deep shade of a beech wood to the open canopy of oak and ash. A complete list would include most, but not all, of the species given for the lowland oak wood (see Part I.). The following plants are characteristic of the Permian woods; others (placed in the second column) are more abundant there than in the lowland oak wood. On comparing the list with that of the scar wood of the Mountain Limestone, it will be seen that a certain proportion occur on both limestone formations, though rarer in the intervening sandstone woods.

LOWLAND MIXED WOODS.

Thalictrum flavum, L. Near water.	*V. Silvestris*, Reich.
Aquilegia vulgaris, L.	*Hypericum hirsutum*, L.
Actæa spicata, L.	*Euonymus europæus*, L.
Viola hirta, L.	*Cornus sanguinea*, L.

LOWLAND MIXED WOODS.

Inula Conyza, DC.
Atropa Belladonna, L.
Daphne Laureola, L.
Narcissus Pseudo-narcissus, L.
Polygonatum multiflorum, All.
Carex digitata, L.
Calamogrostis epigeios, Roth.
Scolopendrium vulgare, Symons.
Ranunculus auricomus, L.
Adoxa Moschatellina, L.
Neottia Nidus-avis, Rich.
Listera ovata, R. Br.
Epipactis latifolia, All.
Habenaria chloroleuca, Rid.
Convallaria majalis, Weber
Arum maculatum, L.
Carex sylvatica, Huds.
Festuca sylvatica, Vill.
Hordeum sylvaticum, Huds.

The prevalence of the beech on the Permian suggests that it may be native there. This is the opinion of Mr. Lees (1888), who considers it as a denizen on the other formations in West Yorkshire. Mr. Baker (1885) says, "The beech is less likely to be indigenous with us than the sycamore;" he regards it as a denizen in North Yorkshire. Mr. Robinson (1902) gives it as native in the East Riding: "the tree of the Wolds, and, although much planted now, is most likely aboriginal, as on the chalk further south." He also gives old place-names in confirmation. It seems, therefore, possible that in or near the eastern part of this district, the beech is indigenous. The subject is worthy of a fuller examination than we can give it here. Dr. Höck (1892), in a series of papers dealing with the associate-plants of beech forest, points out that these are difficult to distinguish from those of (1) the oak, and (2) the alder associations. This we have also experienced in Yorkshire. In order to determine the true associates of the beech, Höck examines the distribution of sixty-eight plants found in beech woods of Northern Germany, in comparison with that of the beech itself. He distinguishes twenty-one species which are closely co-extensive with the distribution of indigenous beech in Europe, from forty-seven species which have a wider distribution, and probably belong to the associations of the oak or alder. We have compared Höck's lists with the Floras of the West and East Ridings, and find that of the twenty-one close associates of the European beech forest, only ten are admitted as natives of the West Riding, while only eight are natives of the East Riding. Whether this method is the best one for determining the range of native beech requires confirmation; but if it is reliable, then it does not support the claim that beech is native in Yorkshire. The beech is, nevertheless, a common tree in the lowland woods, and grows well. It is also frequently found in the valleys, where it has been planted. In the valley of the Burn on Lord Masham's estate beech is successfully grown in close plantations with Scots pine and larch, up to an altitude of 850 feet. The highest altitudes for beech in this district are: 1000 feet (304 metres) between the Washburn and the Nidd, where it is planted with other trees in shelter-belts; and about 1300 feet (400 metres) at Malham Tarn House. On Rainstang,

in Upper Nidderdale, there is a small clump planted by the roadside in an exposed position about 1350 feet; when or why these beeches have been planted we could not ascertain, but at present they are about 20 feet high, and have remained about this height for thirty years at least.

The Hazel Copse of the Permian.—The Permian soils are good farmland, and few uncultivated places large enough to show on the map are to be found. Hook Moor, near Aberford, is almost the only moor-like locality on the Permian. The vegetation found on it (see Part I.) is that of a grassy common, but the presence of indigenous shrubs indicates the rudiments of a copse vegetation. Uncultivated places of small extent are to be found along steep banks and in numerous disused quarries from which limestone was at one time extensively quarried. Wherever grazing is restricted, these waste places tend to become open thickets of hazel, hawthorn, bramble, and rose. In the conditions thus formed, there is a varied vegetation, which includes the following, as well as plants of the Permian pasture.

Corylus Avellana, L. Dominant.
Ranunculus Auricomus, L.
Helleborus viridis, L. Local.
Arabis hirsuta, Scop.
Reseda lutea, L.
R. Luteola, L.
Helianthemum Chamæcistus, Mill.
Viola odorata, L.
V. hirta, L.
Cerastium arvense, L.
Hypericum montanum, L.
Geranium sanguineum, L.
G. columbinum, L.
Euonymus europæus, L.
Rhamnus catharticus, L.
Ononis spinosa, L.
Anthyllis Vulneraria, L.
Astragalus glycyphyllos, L.
Rubus cæsius, L.
Rosa spinosissima, L.
R. mollis, Sm.
Cratægus Oxyacantha, L.
Saxifraga tridactylites, L.
Galium Mollugo, L.
Asperula cynanchica, L.
Scabiosa Columbaria, L.
S. arvensis, L.
Carduus nutans, L.
C. Crispus, L.
Centaurea scabiosa, L.
Hieracium Pilosella, L.
Ligustrum vulgare, L.
Blackstonia perfoliata, Huds.
Cynoglossum officinale, L. Rare.
Lithospermum officinale, L. Local.
Echium vulgare, L.
Atropa Belladonna, L.
Verbascum Thapsus, L.
Origanum vulgare, L.
Calamintha officinalis, Moench.
Listera ovata. R. Br.
Orchis pyramidalis, L.
Ophrys apifera, Huds.
O. muscifera, Huds.
Carex sylvatica, Huds.
C. flacca, Schreb.
Bromus ramosus, Huds.
B. erectus, Huds.
Brachypodium pinnatum, Beauv.
Asplenium Ruta-muraria, L.

The Permian Hedgerow.—The hedges of the numerous old lanes on the Permian tract merit a passing glance, because they are a characteristic feature, and frequently enable one to determine with considerable accuracy the limits of that formation. In the upland districts of Yorkshire, there are few hedges and many stone walls (dark on the Millstone Grit, white on the Mountain Limestone), and behind these a limited number of plants are sheltered. The hedges of the lowland

Coal Measures consist chiefly of hawthorn, and are not rich in associates. The following are constituents of the hedges on the Permian :—

Clematis Vitalba, L. Rare.
Berberis vulgaris, L.
Euonymus europæus, L.
Rhamnus catharticus, L.
Acer campestre, L.
Rubus, spp.
Rosa, spp.
Prunus spinosa, L.
Cratægus Oxyacantha, L.
Bryonia dioica, Jacq.
Cornus sanguinea, L.
Viburnum Opulus, L.
V. Lantana, L.
Sambucus nigra, L.
Lonicera Periclymenum, L.
Fraxinus excelsior, L.
Ligustrum vulgare, L.
Convolvulus sepium, Junger.
Solanum Dulcamara, L.
Daphne Laureola, L.
Ulmus montana, Stokes.
U. suberosa, Ehrh.
Humulus lupulus, L.
Corylus Avellana, L.
Tamus communis, L.

The hedgerow vegetation is a composite one. Trees, shrubs, and climbing plants from the woods and copses make up the hedge itself. The undergrowth consists of plants from the woods and copses, weeds from the farmland fields and meadows, and ruderal or wayside plants. The elements of a hedge thus represent the common associations of a locality, and by observing them one may obtain information useful in a botanical survey.

C. The Farmland or Area of Cultivation.

The Board of Agriculture returns, already given in Part I., indicate the crops of the farmland. The rich warm soils of the Permian tract are amongst the best in the West Riding, and here the greatest proportion of arable land occurs. The soils on the Trias are so variable, from the presence of glacial or alluvial *débris*, that one finds fields capable of carrying good crops quite close to those with poor soils. This is very marked along the river Ouse, and round York rye is a common cereal crop, while everywhere rough derelict pastures may be found. West of the Permian, the grassland increases as the moorland is approached. The highest enclosed farmland occurs on the tract of limestone between Grassington and Pateley Bridge at an altitude of 1400 feet, and at the head of Nidderdale at 1500 feet (456 metres). The cultivation of wheat in this district is carried on almost up to the eastern edge of the moorland, and far up the bottoms of the dales. The occurrence of wheat cultivation so far up the eastern moor edge is partly due to the low annual rainfall, which along this tract is not much above 30 inches. The favourable exposure and the long undulating slopes are also important factors. The upper limit of wheat here varies from 600 to 700 feet. A crop in 1901 at High Skelden (700 feet) was a successful one. We have also a record on good authority that wheat is regularly and successfully grown at 800 feet at High Bramley Grange, near Masham. The climatic conditions of these eastern slopes seem suited for wheat, and, with a more favourable

market, it could be grown on the better soils even higher than we have indicated on the map. In the dales, wheat is at present rarely grown. The records in Airedale round Skipton were kindly placed at our disposal by Mr. R. B. Cragg, who obtained them from old and trustworthy documents. Thus we have been able to give the wheat-limits in this neighbourhood with considerable accuracy. In Wharfedale the highest recent record obtained by us was at Ilkley, but from reliable information the wheat zone has been carried up to Burnsall, where it was grown about forty years ago. Mr. Cragg also obtained records of wheat cultivation on the alluvial lands by the Wharfe near Grassington. In Nidderdale it seems improbable that wheat was ever cultivated further up than Pateley Bridge; the limits shown on the map are based on our own recent observations.

The Permian Pastures.—In early summer the vivid bright green of the pastures, and the reddish soil of the ploughed fields of the Permian, are distinct from the darker pastures and soils of the Coal Measures. On the Permian pastures the grasses are short, and form a compact sward, which includes many plants besides grasses, the soil is easily warmed by solar radiation, and spring growth begins early. The Coal Measure soils, on the other hand, are retentive of water, remaining cool and moist, and growth begins later; the grasses are more tufted (*e.g.* Agrostis and Cocksfoot), and retain their dead leaves till early summer. The vegetation of an old Permian pasture contains many plants which grow best in dry well-drained places, and are either absent or rare on the adjoining formations. The pasture consists of plants able to withstand moderate grazing. In the absence of grazing, other plants appear, and the vegetation becomes that of a grassy common, like Hook Moor (Part I.), or that of the hazel copse.

The following are found chiefly on Permian pastures :—

Ranunculus bulbosus, L.
Polygala vulgaris, L.
Anthyllis Vulneraria, L.
Astragalus danicus, Retz.
Spiræa Filipendula, L.
Potentilla verna, L.
Poterium Sanguisorba, L.
P. officinale, Hook.
Saxifraga granulata, L.
Pimpinella Saxifraga, L.
Scabiosa Columbaria, L.
Senecio erucifolius, L.
Carduus crispus, L.
Cnicus eriophorus, Roth.
Campanula glomerata, L.
Primula veris, L.
Erythræa Centaurium, Pers.
Gentiana Amarella, L.
Rhinanthus Crista-galli, L.
Thymus Serpyllum, Fr.
Plantago media, L.
Orchis ustulata, L.
O. Morio, L.
Habenaria conopsea, Benth.
H. viridis, R. Br.
Allium Scorodoprasum, L.
A. oleraceum, L.
Colchicum autumnale, L.
Carex verna, Chaix.
Anthoxanthum odoratum, L.
Aira caryophyllea, L.
Trisetum pratense, Pers.
Avena pubescens, Huds.
Cynosurus cristatus, L.
Koeleria cristata, Pers.
Briza media, L.
Festuca elatior, L.
Bromus erectus, Huds.
Hordeum secalinum, Schreb.
Poa pratensis, L.

Uncultivated Lands.—Here and there amidst cultivation, patches of land are met with which have never been cultivated. The heaths or commons of the Millstone Grit and the Coal Measures have already been referred to in Part I. Examples also occur in this district. The uncultivated lands of the Permian are examples either of the hazel copse, the grassy pasture, or the Permian common.

Aquatic and Marsh Vegetation.—The chief features of this in its upland and lowland aspects were given in Part I. In this district, however, there is a much better development of the lowland type. The rivers, after traversing the Permian limestone through wooded gorges, such as those at Knaresboro' and Boston Spa, pass on to a flat plain, through which they flow slowly and with many windings. Owing to drainage and cultivation, the aquatic and marsh vegetation is now almost restricted to small areas. Askham Bog, near York (not included in the present district), probably represents what was formerly a common feature in the Plain of York. It has been briefly described thus: "Pools bordered by flags, sedges, bulrushes, and marsh ferns, jungles of *Osmunda*, with birch, willow, and blackthorn. . . . The Bog is a tangled mass of flags and sweet gale, and various low-growing trees" (Rev. W. C. Hey, *Trans. Y.N.U.*, 1900). Within the limits of our map, the Ure from Ripon, and the Ouse with its tributaries, furnish good examples of aquatic vegetation. Still reaches of water offer suitable conditions for floating and submerged aquatics, and the reed-swamp of tall grasses and bulrushes, while willow thickets shelter many plants of the marsh. Representative lists have already been given in Part I., but in this district the species named are more abundant, and the number could be considerably increased. Amongst others which might be added are—the white and yellow water-lilies, and several species of *Potamogeton;* and of the marsh plants the greater spearwort (*Ranunculus Lingua*), marsh buckthorn (*Rhamnus Frangula*), marsh rue (*Thalictrum flavum*), and water-dock (*Rumex Hydrolapathum*). Further consideration of the aquatic and marsh vegetation is deferred, in view of its extensive occurrence in parts not included in our maps.

The geographical distribution of the vegetation in Yorkshire has now been described in two districts, including about a fourth of the county. These districts furnish a general view of the vegetation of the Pennine range and its eastern slopes. In each direction beyond our maps, the vegetation undergoes other changes in its distribution. It is, therefore, convenient to summarize the chief facts presented in Parts I. and II.

I. Farmland.

A. With Wheat Cultivation: upper limits, 600 to 700 feet (182 to 213 metres), except in the dales.

B. Without Wheat Cultivation: upper limits, 1000 to 1100 feet

(304 to 333 metres), with occasional extension up to 1500 feet (456 metres).

II. Woodland.

A. Deciduous Woods :—

1. Lowland Oak Wood and Mixed Deciduous Woods: upper limits, 500 to 600 feet (152 to 182 metres); occasional mixed woods (planted), up to 1000 feet (304 metres).
2. Upland Oak Wood: upper limits, 800 to 1000 feet (243 to 304 metres); isolated oak, up to 1100 feet (333 metres).
3. Birch Wood of Clough and Gill: upper limits, 1250 feet (380 metres); isolated trees, up to 1550 feet (470 metres).
4. Scar Woods: upper limits, 1000 to 1200 feet (304 to 364 metres).

B. Pine Woods: upper limits, 1250 to 1400 feet (380 to 424 metres).

III. Moorland.

A. Natural Pasture (Limestone): upper limits, 1500 to 1746 feet (456 to 530 metres).

B. Heaths :—

1. Grass Heath: upper limits, 1000 to 1500 feet (304 to 456 metres).
2. Heather Moor: upper limits, 1250 to 1660 feet (380 to 503 metres).

C. Cotton-grass Moor: lower limit, about 1250 feet (380 metres), upper limits, 1500 to 2000 feet (456 to 606 metres).

D. Summits :—

1. Vaccinium: upper limits, 1500 to 1900 feet (456 to 576 metres).
2. Alpine pasture: lower limit, 2000 feet (606 metres), upper limit, 2300 feet (700 metres).

The following natural zones of altitudinal range of vegetation are indicated from the above :—

(1) Zone of Wheat Cultivation and Lowland Oak Wood: upper limit, 500 to 700 feet.

(2) Upland Oak Wood and greater part of Cultivation without Wheat: upper limit, 900 to 1000 feet.

(3) Birch Wood and Pine Wood: upper limit, 1250 feet, which is also the lower limit of the cotton-grass moss.

(4) Heather Moor, Grass Heath, and Limestone Pasture: upper limit, 1500 to 1600 feet.

(5) Cotton-grass moss and Vaccinium Summit: upper limit, 1800 to 2000 feet.

(6) Alpine Pasture, from 2000 to 2300 feet.

In conclusion, we hope that the contribution contained in these two papers may have advanced knowledge in regard to the plant-geography of Yorkshire, and may have suggested methods of observation applicable elsewhere. Defects and oversights must exist, but we have tried to reduce them to a minimum, and trust that they do not affect the main features of the survey.

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THROUGH THE BARREN GROUND OF NORTH-EASTERN CANADA TO THE ARCTIC COAST.*

By DAVID T. HANBURY.

Fort Resolution, near the mouth of the Great Slave river, may be taken as the starting-point in this sketch of my journey through the Barren

* See map, p. 236.

Ground of North-Eastern Canada. From this station, on July 13, 1901, I and the two companions whom I had engaged set out in two light canoes, with a small scientific equipment and with only such supplies as were strictly necessary for the earlier part of the journey. For the expedition to the arctic coast I had arranged that ample stores should be waiting in winter on board a whaling schooner, the *Francis Allyn*, somewhere near the mouth of Chesterfield inlet, probably at Marble island.

The first evening we camped on Stony island. In crossing the lake we passed a long group of small islands, which I had not seen on any map. On the north shore, as we paddled along, we found traces of the gold bubble which had risen and burst a few years before. On July 20

VIEW OF TYPICAL COAST, BARREN GROUND.

we reached the eastern end of the lake. Then we made the nine portages, one of them $2\frac{1}{2}$ miles long, and on the 23rd reached Artillery lake, whose lovely blue waters rippled in bright sunshine, while on either hand the so-called Barren Ground stretched green and gay with numberless wild flowers. Ascending the stream which flows into the lake, we reached the watershed on the 27th, and in the evening camped on Campbell lake, on the headwaters of the Ark-i-linik. The divide is only a low moss swale, about 300 yards across, where one could just observe the water trickling here to the west, there to the east. Next day we reached the irregularly shaped lake which I have called Abbott lake, and, on the following morning, proceeded down the western branch of the Ark-i-linik. A few miles east of Abbott lake, I found, as I had found in 1899, that my compass would not work; but after trying a few blind inlets, we made out the proper course. On the 29th we saw the first of

the spruce trees which distinguish the Ark-i-linik down to about 20 miles west of Ti-bi-ilik lake, forming in many places a belt or fringe of woodland, the trees being sometimes as much as 2 feet thick at the ground.

On August 2 we reached a portage where the river cuts its way through felspathic granite (quartz in some places, in others biotite), whose beds dip at an angle of 60°. At the foot of the portage the formation changes to white sandstone, which continues with little interruption to the mouth of the main river. By August 5 we had passed all the portages, including that at a fall 30 feet high, and commenced (August 6) the descent of the main river.

On the 15th, near Ti-bi-elik lake, we met the first Eskimo, or Huskies, as I shall call them. Descending the lake, which is 13 miles long and 5 or 6 miles broad, we reached the mouth of the Dubawnt river, whose name is then given to the united stream. Accompanied by two Huskies, we held on our way, and on the 20th reached Udi-uk-tellig, a Husky camp, where, in conversation with my old friend Amer-or-yuak, I recovered my knowledge of the Husky language. We were detained by rain and wind (north-north-east and north-west), usual at this season, till August 25, when we resumed our journey. The river connecting with Baker lake is wide, deep, and swift, with steeply sloping banks, the country, especially on the north, being hilly and rocky. Halfway down the lake we were delayed by bad weather, then we had fog; but, steering by compass, we reached Maur-en-ek-uak, at the foot of the lake, on September 3.

Here the tide from Hudson bay rises 6 or 8 feet. Chesterfield inlet commences about 20 miles further down, at the end of the southern outlet of Baker lake. This channel, the last portion of the Dubawnt river, is deep, and the water flows with a strong current. With a fair wind we descended the inlet in three days, and (September 8) camped on the mainland coast, south of Fairway island. Back from the coast the land was undulating, stony, and rocky, dotted with small lakes and moss swamps. Birds (ducks, etc.) were numerous, and one day I stalked and shot a swan belonging to one of the flocks I had seen overhead. Having gone southwards looking for the whaler, we set out, on September 17, in calm weather, and crossed the channel (about 10 miles) to Marble island, rounded its south-western point, and entered the narrow passage leading to the harbour, but no ship nor any living creature was there, though barrel hoops and staves were lying about, and there were many graves. The island is of quartzite, white at a distance, but rusty or yellow close at hand. The harbour is good, except that its anchorage is insufficient, and we saw a track leading up the rocks to a small fresh-water lake.

Returning to the mainland, we resolved to go back, in the mean time, to Baker lake. Near the coast we found indications, chiefly in the form

VIEW OF THE COUNTRY ON KENT PENINSULA.

VIEW OF MOUNT HAR-LI-AR-LI (BASALT), KENT PENINSULA. ALTITUDE, 360 FEET.

of old Husky camps, that the Hudson bay Huskies are less numerous than formerly, and my inferences on this subject were confirmed by Amer-or-yuak. Proceeding up the inlet, I met at Nell-yuk-yuak, on September 28, Uttungerlah, an old Husky friend, and received from him letters which informed me that the *Francis Allyn* was lying at Dépôt island, a small, low rocky islet about 40 miles north of the mouth of the inlet. He had come in one of the whale-boats, and in this craft I reached the whaler on October 2. Three days later we set out in a fully laden whale-boat, and took a short cut along a shallow channel dug by the Huskies behind the peninsula (which maps do not show as a peninsula) at the north-end of the inlet, thus saving 20 miles. On October 12 we reached the Husky camp at the foot of Baker lake, and landed through heavy slob ice, just in time, for next day the river was frozen thick.

In the winter we had several hunting expeditions, one being towards Pelly lake, over new ground, which in this brief sketch I must leave undescribed.

My next move (December 26) was towards the *Francis Allyn*, where I had to prepare for the journey to the arctic coast. I made arrangements with Amer and Uttungerlah for their company to the north, settled on the route and other details, and then went to fetch the supplies. From the head of Chesterfield inlet to the ship the direct distance was about 140 miles, which, in travelling, we made about 180. The country was flat or undulating, and contained lakes, but neither our going nor returning need be described here. For the month of January, 1902, the mean temperature was $-30°{\cdot}5$ Fahr., and the lowest reading for the whole winter was $-57°$ Fahr.

On March 9 we started on our long journey from the foot of Baker lake with two sleighs laden with stores, and a third carrying two canoes "nesting" on a frame, the three being drawn by twenty dogs. All of us walked, even the women and children who were to accompany us to Pelly lake. We went by easy stages, and on the 16th reached King-ak, near the lake-head. Here the minimum temperature was $-51°$ Fahr. The whole southern shore of the lake is low, but about 2 miles to the south, a ridge parallel with it runs from near the Kazan river to King-ak, and opposite the middle of this ridge, but 8 or 10 miles to the south, is a conspicuous hill called No-a-shak.

King-ak stands on a bay, into which flows a very small stream. This is probably the place referred to by Captain Christopher, sent in 1761 to ascertain whether a north-west passage could be found by Chesterfield inlet. He mentions, as at the head of a large fresh-water lake (Baker lake), "a small river full of falls and shoals, not water for a boat," and seems not to have seen or heard of the Dubawnt river.

Travelling slowly past the shores of Schultz lake and Aberdeen lake, we reached Ti-bi-elik lake on April 3. Here three thermometers

MOUTH OF THE COPPERMINE RIVER.

PRECIPITOUS COLUMNAR BASALT OVERLYING LIMESTONE, PORDEN ISLANDS, BATHURST INLET.

gave 211°·4 as the boiling-point, the temperature of the air being 32°, so that the altitude was about 313 feet. On April 5 we crossed the lake (6 miles), and next day set out due north, intending to follow the meridian of 101° as nearly as we could by dead reckoning. The country was flat, without rocks *in situ*, but red sandstone *débris* appeared. In 9 miles we found only one lake. Further on (April 7), the sandstone *débris* gave place to granite boulders and fragments. The boiling-point of two thermometers here was 211°, the air being at 28°, so that the altitude was about 515 feet.

On the 8th we crossed two small lakes and a low ridge, apparently dividing the waters flowing south from those flowing north to Back's river. The country was still flat, with low ridges and sand-hillocks. Next day we struck and followed a river flowing north. It proved to be the Buchanan, with banks usually low and sloping, but high in some places, with sandy hills back from either side. The ice on the river was 7 feet thick. On the 10th we camped in snow huts on a lake, to the west of which was a flat-topped gravel hill about 120 feet high. As we descended the river, its bed of granite boulders widened, and was now from 300 to 600 yards across. I could not determine my longitude, and was puzzled by the discrepancies between Tyrrell's map and the latest Admiralty chart, the mouth of the Buchanan being put on the former at 102° 10′ W., and on the latter at 103° 10′ W.

On April 12 we fell in with a Back's river Husky, who took us to his camp. On the 14th we left the Buchanan, and, going 5 miles north-east, reached the south-west shore of Pelly lake, across which we travelled 6 miles to the north shore. Here the boiling-point given by two thermometers was 211°·5, the temperature of the air being 30°, so that the altitude was about 260 feet. We searched for, but, owing to fog, did not find, a stream which we were told flows into Pelly lake from the north. On the 18th we followed an arm of the lake running north; then struck north and north-north-west, where the land became rugged with granitic rocks. On the 17th the maximum temperature had reached 32° Fahr., and on the 20th 36° Fahr. On the 21st an observation of the meridian altitude of the sun showed we were in lat. 66° 25′ 25″ N. Here the boiling-point was 211°·2, the air being at 29°, and the altitude therefore about 414 feet.

Then the country became flat, and on the 22nd we reached Te-her-uak lake (but this seems to be a common word for "lake"). Travelling $8\frac{1}{2}$ miles from about the middle of the shore, we reached the foot of the lake, which, confined within low rocky shores, was irregular in shape, and contained many rocky islands. Next day we found the outlet, marked with stones set on end by Huskies. As we travelled northwards, April 23, it was difficult to tell whether we were on the river, or on lakes or moss swamps. An observation gave our latitude as 66° 42′ N., so that from Ogden bay in 67° 36′ N. we were distant 54 geographical

COPPERMINE RIVER.

miles. The rocks here were pinkish felspathic, smooth, but not striated so far as we observed. On the 25th we travelled on the river and lakes across a barren country with neither moss nor lichen, but we found heather for fuel. For several days we were detained by blizzards, but on May 1 we continued our way down the river past several frozen rapids, the rocky banks being sometimes 20 feet high. On May 2 we were in lat. 67° 18′ N. We made long halts to avoid outstripping the deer in their migration to the north, and on one of these days I killed two arctic hares on rough broken ground. On the 8th we were nearly at the sea-level, two thermometers giving 212° as the boiling-point, and one 212°·1.

On the 10th we were about 67° 26′ N., or about 10 geographical miles from Ogden bay, and I sent two Huskies north to prospect, giving them presents for the coast natives. Next evening they returned, bringing with them two coast Huskies, tall, strong, quiet men, differing in no way but in the cut of their clothes from the Hudson bay men. They seemed timid at first, but gained confidence, gave me much information, and agreed to accompany us.

On May 12 we were in lat. 67° 29′ and two days later we struck the arctic coast in lat. 67° 44′; and (as I subsequently puzzled out) at a spot a little to the west of McTavish point. The river had widened out, and the land was very low. Seven miles out on the ice we found a Husky camp of two snow huts, or "iglûs," and three tents, containing

five families and some visitors, forty-five persons in all. From that point our direction was westwards. Setting out on the 16th, we passed many bare, rocky islets, the distant mainland coast being visible as a low undulating ridge. On the 17th we camped beside rocky islets showing deep grooves and striæ, and broken off abruptly to the north. Other two days' travelling brought us to the tents of Huskies, strangers to my Arctic coast companions, and bearing a marked resemblance to the Mongolian type. They were friendly enough, but did not invite us into their tents. On May 22 I found we were in lat. 68° 5′. Here we boiled three thermometers, which showed respectively 212°, 212°·1, and 212° as the boiling-point.

After being detained by blizzards, we cut across White Bear point, and held for two days westwards, inclining slightly to the north. On May 27 we camped in our tent on the west of the portage across Bear

SMALL WATERFALL COMING INTO THE COPPERMINE RIVER.

point, and on the 28th, at some island rocks to the west of Dease point, we saw the midnight sun for the first time, though it had been visible

THE DIVIDE BETWEEN GREAT BEAR LAKE AND THE COPPERMINE RIVER. VIEW LOOKING NORTH TOWARDS DISMAL LAKE.

some days earlier. The mainland to the south seemed high and rocky; Melbourne island appeared as a long low streak to the north.

On May 29 I found our latitude was 68° 29′. That day we reached the east coast of Kent peninsula, where Huskies were busy catching codling with copper hooks through holes in the ice. The weather was now warm; the blazing sun melted the snow on the land, pools of water lay on the ice, and birds and beasts became more numerous.

The little inlet from Labyrinth bay on which we were camping was almost too small to have a name, but as, from its position, it seemed to deserve one, I called it Portage inlet. From its head there is only one mile's distance overland to It-ib-lair-yuak lake, which is 6 miles long, and has at its west end an outlet flowing into the inlet E-lu from Warrender Bay, on the west side of Kent peninsula, which is thus almost an island. With exception of the one-mile portage, there is an excellent canoe route, not only much shorter, but more sheltered than that round Kent peninsula.

We resumed our journey on May 31, and camped at the foot of the lake in a rocky country. A mile to the south-south-west was a basaltic hill (Har-li-ar-li) 360 feet high, as I made out by the Watkin aneroid, and precipitously cut on the east and south. On the ridges and hills here beds of marine shells were noticeable. Travelling along the south shore of the inlet E-lu, we passed on June 4 a hill called U-wei-yu-ullu, and on June 6 a similar hill, both being precipitous nearly all round,

and though less than 600 feet high, very prominent landmarks. About 9 miles further on, the E-lu inlet, which is about 12 miles across at its widest part, contracted to about 1½ mile. The following day (June 7), after going 8 miles, we reached Warrender bay. The entrance to E-lu inlet is obscured by islands overlapping one another, and this fact accounts for its having been passed unnoticed by the surveyors of Melville sound. Crossing Hope bay, we went S. 30° W. to the high and rocky south shore of Melville sound, travelling 22 miles over smooth ice, on which a Husky killed five arctic hares with his bow and arrow. On the 8th we travelled west along the coast of the sound, and camped at a creek with a shoal sandy beach, where there was a Husky encampment called Sarker-wark-tûk. A longish hill, 840 feet high, overlooked our camp. Dwarf black birch was abundant.

On the 15th I and two Huskies on a sleigh set out for Barry island (Iglor-yu-ullig), and next day reached its north shore. We found two small pieces of copper, and the rock formation showed that the metal was abundant and widely distributed. In returning (June 18) we made for the nearest land on the eastern shore of Bathurst inlet, and, crossing mountainous ground, reached our camp on the 19th. On the 22nd we journeyed 18 miles westwards, and camped on the west side of Cape Croker, which is an island separated from the mainland by a channel half a mile wide. Next day, in crossing Bathurst inlet, we reached a flat-topped precipitous island, basaltic, but with a bed of limestone as much as 60 feet thick underlying the columnar basalt. On the 25th, passing many other islands, we reached one where we searched for copper, and, though we found little, saw from the stains on the rocks that copper was present. On the 27th, at the north-west point of Lewes island, we found copper in flakes wedged vertically in the rocks, and also in small chunks. We picked up between 2 and 3 lbs. in less than three-quarters of an hour. The rock was easily cleft by a slight tap with an axe. The summer was now well advanced, birds, butterflies, and flowering plants being common.

On the 29th we reached Cape Barrow, off which are precipitous basaltic islands, and inland from which the country is rugged. Next day, 8 miles along the coast, at Utkûshik Karlûk, we found a soft stone from which the Huskies make kettles (*Utkûshik*). It occurs, grey and powdery-looking, among granitic rocks. On July 1 we camped a short distance east of Uni-a-lik, a river with a reputation for salmon. Here, in Gray bay, the ice was very rotten; but next day, beyond Hepburn island, the ice was good. As we advanced, however, it got worse. We all went through it several times, and the cracks became so wide that in crossing them we had to launch a canoe. Two of us were suffering from snow-blindness, and when less than 60 geographical miles from the Coppermine river mouth, I resolved to wait for open water. On the 12th we set out in the canoes, but the strip of open water was not

continuous, and it was not till the 18th that, after many portages, we reached the Coppermine.

Next day we paddled 9 miles up to Bloody fall, where we found a Husky camp, from which the occupants had fled on our approach, leaving everything behind. The stone kettles with boiled salmon were still warm. I took some half-dried salmon, and left for payment knives, files, needles, etc.

The fall is in fact a rapid, requiring half a mile's portage. Above this is a stretch of shoal (now and then deep) water with a swift current, which it took us all day to ascend, wading and walking the canoes. Higher up there were rapids, where the water was too swift

CAÑON AT MOUTH OF KENDALL RIVER.

for paddling and too deep for poling, and where the steep banks gave no footway for tracking, so that portaging could not be avoided. At such places it took all six of us to handle a canoe. We ascended the river for about 100 miles to the place where, nearly opposite each other the Mouse river and the Dismal Lakes river flow into the Coppermine. The river to the west offered fair canoe navigation, and we reached the Dismal lake (there is only one) on August 1. About 12 miles to the north-west we found the narrows, in lat. 67° 21′ N., as I made out. The altitude of the lake is about 860 feet, which is also, within a few feet, the altitude of the divide between the Coppermine and Great Bear lake waters. The portages across the divide were numerous and lengthy, and after having passed them I bade good-bye to the three Hudson bay Huskies who had attended me so far.

On July 29 and August 3 the maximum temperature was 65° Fahr., the highest registered during the journey. I wished to connect the survey of the east end of Great Bear Lake with that of the Coppermine, but scarcity of food and the difficulty of the shoal and stony Dease river required that we should push on. On the 19th we reached Great Bear lake, and on the 30th the long journey ended at Fort Norman, on the McKenzie river.

Generally speaking, the geology of the northland of Canada is not of a very interesting character, except perhaps to the student of glacial phenomena.

Plutonic rocks, granite for the most part, prevail. However, I came on limestone on the arctic coast, but I failed to discover any fossils, though I searched diligently for them. Large quantities of native copper were found on the islands in Bathurst inlet. It was in basaltic formation. I may be wrong about this, as my collection of geological specimens has not been examined yet. As it will be some time before I shall have finished writing up my notes, I have written the following short *resumé* of the different formations met with.

At the foot of Baker lake (Maur-en-ek-uak on my map), red or brown sandstone, classified Cambrian by the Canadian Geological Department. No fossils have ever been discovered. Between the north shore of Baker lake and Lake Garry on Back's river, the usual plutonic rocks occur, chiefly felspathic granite. About 20 miles south of Lake Garry are some exposures of white or grey quartzite, similar to that found on Marble island, which has been reported upon by Dr. Bell (Canadian Geological Survey Department). This quartzite is classed Huronian. As we approached Lake Garry, exposures of rock became less frequent; the land is of a sandy nature, and small sand-hills numerous. Between the head of Chesterfield inlet and Depot island (near Whitney inlet, on the coast of Hudson bay) are massive granite rocks, and the country is rugged.

Starting from the north shore of Ti-bi-elik lake, we travelled over flat or undulating country for 20 miles; no exposures of rock were seen, but sandstone *débris* scattered around. We then came on granitic boulders, but still no rock *in situ*. A short distance further north there was an outcrop of grey quartzite (Marble island). We then struck the headwaters of Buchanan river, a tributary flowing north into Back's river. Along Buchanan river are no rocks *in situ;* land sandy. Granitic rocks are *in situ* on Buchanan river, close to its junction with Back's river. North of Pelly lake, felspathic granitic occurs, smoothed but not striated by glacial action. A similar formation is found right up to Ogden bay on the arctic coast. The granite varies considerably in composition. Felspar is so much in the ascendant in some cases, that the whole country has a pink appearance; in other cases, hornblende is in the ascendant; in others, quartz. The rock is highly crystalline in most cases. Schists are conspicuous by their absence. Plutonic rocks are in evidence all along the arctic coast to Kent peninsula.

A peculiarity which I have noticed in a great many places on the northland of Canada is the occurrence of beds of shells (marine), on the tops of hills or raised spots at altitudes varying from 50 to 500 feet above the sea-level. These beds of shells were very common on Kent peninsula. Specimens of these shells, which I brought back on my last journey, and which were found to the south of Baker lake, were named for me by Dr. Dawson—*Laxicava rugosa* (L.), *Pecten Islandicus*, *Astarte Banksii*, var. *striata*, fragments of Buccinum and Balanus. It has always

been a puzzle to me to account for the presence of these beds of shells. I quote from Lyall, p. 168. "The occurrence of patches and beds of marine shells at altitudes varying from a few feet to 500 feet is probably due, *i.e.* their present elevated condition, to the action of great glaciers or ice-sheets pushing up portions of the sea-floor, possibly in a frozen condition, to the hill slopes on which they are now to be found."

Basalt was observed on Kent peninsula, which continues with breaks almost to the Coppermine river. Native copper is always vertically placed in basaltic formation, much disintegrated, and easily broken up. This formation, containing larger or smaller quantities of native copper, prevails on all the islands in Bathurst inlet (or rather, I should say, all that I visited). I have several specimens of this rock, showing exactly how the copper occurs. It is generally in the form of flakes which are always wedged in vertically, never horizontally. Why this should be so I shall not venture to guess. The copper is also found in lumps or nuggets, some of them very large.

Near Lewis island, in Bathurst inlet, is a bed 15 feet thick of limestone underlying 20 feet of basalt; no fossils in the limestone. In the islands north of the Cape Barrow limestone was seen, but not visited. Eight miles west from Cape Barrow, and about 5 miles inland, there is a spot or patch of soft grey rock, which occurs in felspathic granite formation. I call this rock kettle-stone, for it is the stone used by the Eskimo to make their stone kettles and oil lamps. It is most peculiar and its presence and origin are not very apparent. It is quite soft, and can easily be cut with an axe or knife. It may be the result of the kaolinization of the felspar, caused by deep-seated chemical action. I do not advance this theory, however. Why it should occur at certain spots, or at all, is a geological puzzle. I have specimens of this rock, which is *in situ*, and also a kettle and a lamp made out of it.

The geology along the Coppermine has already been reported upon, I believe. No signs of gold were seen. The only other metal, other than the native copper met with, was iron, which is common everywhere in small quantities.

THE TERMINOLOGY AND NOMENCLATURE OF THE FORMS OF SUB-OCEANIC RELIEF.

THE first meeting of a Committee of the Sixth International Geographical Congress appointed at Berlin in 1899 to consider a scheme of international nomenclature for the forms of sub-oceanic relief was held in the Hotel Nassau, Wiesbaden, on April 15 and 16, 1903.

There were present, H.S.H. The Prince of Monaco; Prof. O Krümmel, Kiel; Prof. A. Supan, Gotha; Prof. O. Pettersson, Stockholm; Prof. Thoulet, Nancy; Dr. H. R. Mill, London. M. Sauerwein, aide-de-camp to the Prince of Monaco, acted as secretary of the Committee. Sir John Murray and Dr. Nansen, members of the Committee, were unable to be present.

The Committee was charged with two duties—

(1) To draw up an authentic map of the oceans, embodying the results of all existing deep-sea soundings, for presentation to the Seventh International Geographical Congress at Washington in 1904.

(2) To consider a system of international terminology and nomenclature for the larger features of sub-oceanic relief.

(1) Prof. Thoulet brought forward a scheme for constructing a chart of the oceans on the equatorial scale of 1: 10,000,000 (approximately 160 miles to an inch), two different projections being adopted. From 72° S. to 72° N. the chart would be on Mercator's projection, and would comprise twenty-four sheets. From 72° to the poles the gnomonic projection would be employed, each polar area including four sheets, so that the whole map would consist of thirty-two sheets of a convenient size. All soundings of greater depth than 1000 metres would be entered upon the chart, and isobathic lines drawn so far as the data warranted. The unexplored part of the oceans would be left without isobathic lines, and it was proposed to issue the map uncoloured. It was understood that the Prince of Monaco would be responsible for the production of this map, should the Washington Congress approve of the scheme.

After a prolonged discussion of the scale and the projections, the Committee unanimously resolved to recommend the Congress to adopt Prof. Thoulet's scheme in its entirety. It also recommended that the data of the new map should be published on an equivalent area projection on a smaller scale, suitable for the use of oceanographers in plotting various distributions for the purpose of measuring areas. It was suggested that this might be undertaken by private enterprise.

(2) As regards terminology, it was resolved to ask the German members of the Committee to draw up definitions of the terms used for the more important forms of sub-oceanic relief, and to communicate them to the other members for consideration and for consultation with other geographers. When the definitions are adopted, the Committee should decide as to exact equivalents of the terms in French and English.

It was resolved to recommend that for the larger features names descriptive of their geographical positions should be exclusively adopted, as has been done in Prof. Supan's bathymetrical chart published in 1899. For smaller features and for special points the names of persons or of ships might be freely used.

The following is the terminology (with definitions) of the most important forms of sub-oceanic relief, proposed by Prof. Supan, with the English equivalents suggested by Dr. H. R. Mill, and the French by Prof. Thoulet.

I. The Greater Forms.

1. The **Shelf** (Ger. *Schelf;* Fr. *Socle* or *Plateau continental*) is the only form of the continental border which is of independent importance. It is the portion of the continental border which extends seaward from tide-marks, sinking very gradually, as a rule, to the depth of about 100 fathoms or 200 metres, and then suddenly falling steeply to a great depth. Examples: the British, Sunda, and Newfoundland shelves.

2. The **Depression** (Ger. *Vertiefung*) is enclosed on all sides by elevations of the sea-bed.

(*a*) The *Basin* (Ger. *Becken;* Fr. *Bassin*) is a depression of approximately round form, in which the horizontal diameters are about equal.

(*b*) The *Trough* (Ger. *Mulde;* Fr. *Vallée*), an elongated and wide depression, with gently sloping borders. A trough may be divided by transverse elevations into basins, as, for example, in the Atlantic.

(*c*) The *Trench* (Ger. *Graben;* Fr. *Ravin*) is also an elongated but proportionally narrow depression, with steeply sloping borders, one of which (the continental) rises higher than the other (the oceanic). Trenches are the ends of unsymmetrical basins, and lie beside the continental border or island chains. The Cayman trench alone runs between islands, but in its case also the borders are of unequal height. Strictly speaking, the trench is only a secondary form of the great depressions of the ocean floor, but on account of its considerable length, its depth, and its genetic importance, it may well be reckoned as one of the principal forms.

The extension of a trough or basin which penetrates the land or a submarine elevation, either with a uniform or a gradually diminishing depth, or which is bounded on the one side by land and on the other by a submarine elevation, may be—

(*a*) An *Embayment* (Ger. *Bucht;* Fr. *Golfe*), if wide, and of a rounded or triangular form, as, for example, the East Australian embayment.

(*b*) A *Gully* (Ger. *Rinne;* Fr. *Chenal*), if long and narrow (*e.g.* the Färoe gully, the Norwegian gully).

3. The **Elevation** (Ger. *Erhebung*) is either entirely surrounded by depressions or is a prolongation of the continental border.

(*a*) The *Rise* (Ger. *Schwelle;* Fr. *Seuil*) is an elevation which rises gradually with an angle of only a few minutes of arc, irrespective of whether it is wide or narrow, or of its vertical development. On account of its flatness the rise apparently plays only a subordinate part, but rises carry the chief features of suboceanic relief, so that if the ocean floor was changed into dry land they would act as the main watersheds.

(*b*) The *Ridge* (Ger. *Rücken;* Fr. *Crête*) is a relatively narrow elevation which is prominent on account of the steep angle at which it rises. It is thus narrower than an extended rise, the distinction being clear where a rise assumes in some parts the character of a ridge, as, for example, the Atlantic equatorial ridge. The category of ridges includes both greater and minor forms.

(*c*) The *Plateau* (Ger. and Fr. *Plateau*) is a steep elevation of large extent in which the length and breadth do not greatly differ. It may rise from the depressions of the ocean floor, or from a rise (*e.g.* the Azores Plateau).

4. A *Deep* (Ger *Tief;* Fr. *Fosse*) is the deepest part of a depression (*e.g.* the Nero Deep). A *Height* (Ger. *Höh;* Fr. *Haut*) is similarly the highest part of a rise, ridge, or plateau, if it does not belong to the base of an island or is classed as an independent minor form (*e.g.* the Valdivia Height on the Walfisch Ridge).

II. Minor Forms which are of smaller extent, but, on account of steeper slopes, clearly distinguished from their surroundings, include—

1. **Elevations**:

(*a*) Elongated elevations usually of irregular surface: Ridges.

(*b*) Single elevations or submarine mountains, particularly—

(α) The *Dome* (Ger. *Kuppe;* Fr. *Dome*), an elevation of small area, but rising with a steep angle to a depth more than 200 metres from the surface.

(β) The *Bank* (Ger. *Bank;* Fr. *Banc*) rising to within 200 metres of the surface, but not so far as within 11 metres (*e.g.* the Porcupine Bank, or Princesse Alice Bank).

(γ) The *Shoal* (Ger. *Grund;* Fr. *Haut fond*) and *Reef* (Ger. *Riff;* Fr. *Récif*), which come within 11 metres of the surface, and so are dangerous to shipping (*e.g.* Paracels Reef, Adler Shoal).

2. **Depressions**:

(*a*) The *Caldron* (Ger. *Kessel;* Fr. *Caldeira*), a more or less steep depression of relatively small extent (*e.g.* the Monaco Caldron on the Azores Plateau).

(*b*) The *Furrow* (Ger. *Furche;* Fr. *Sillon*), a valley or channel-like hollow in the continental border, and more or less at right angles to it (*e.g.* the Indus Furrow, the Ganges Furrow).

The opinion of geographers as to the appropriateness of this terminology, or as to the best synonyms of the German terms is asked for.

MAP OF SOUTH-WEST CHINA, TO ACCOMPANY CAPTAIN RYDER'S PAPER.*

THE map of South-West China and parts of adjacent countries, which appears in the present number (p. 236), is intended to accompany the paper by Captain C. H. D. Ryder, R.E., read before the Society on November 24 last, and published in the February number of the *Geographical Journal* for this year. It has been reduced from thirty-four sheets of the North-Eastern and South-Eastern Frontier surveys, on the scale of 4 miles to an inch, now being published under the direction of the Surveyor-General of India, through whose kindness the Society has been furnished with advance copies. These sheets have been drawn from the recent surveys of Captain C. H. D. Ryder, R.E., Major H. R. Davies, OXFORD L.I., Captain W. A. Watts Jones, R.E., Captain L. D. Fraser, R.A., Major T. F. B. Renny-Tailyour, R.E., and other officers of the Indian Survey, supplemented in parts from the route surveys of the late Captain W. J. Gill, R.E., Mr. C. Baber, the Pandit "A. K.," Prince Henry of Orleans, Dr. Logan Jock, and other travellers. No attempt has been made to show boundaries, except where they have been definitely fixed.

In the spelling of the place-names care has been taken to follow as far as possible the special rules for Chinese names laid down by this Society.

THE GERMAN ANTARCTIC EXPEDITION.

THE official report of Dr. von Drygalski has been received in Berlin, and was printed on July 10 as a supplement to the *Reichsanzeiger*. It begins with the departure from Kerguelen on January 31, 1902, and describes the voyage *viâ* Heard island (where a landing was effected, and a study made of the glaciers, animal life, etc.) to the position in which Termination Land had been thought by Wilkes to exist, though the voyage of the *Challenger* had thrown some doubt on the subject. The voyage was not made without difficulties; the pack-ice, which was reached on February 13 in 61° 58′ S., 95° 8′ E., for a time preventing any great progress in a southerly direction. Dr. von Drygalski is of opinion that the belief of the existence of Termination Land originated in the deceptive appearance of the icebergs, of which many were seen in the neighbourhood by the German explorers. Although the soundings showed smaller depths than had been met with previously, they were still too great to allow of the supposition that land was close, though from the nature of the icebergs it is thought probable that it existed at no very great distance. On February 18 a more rapid advance began, and on the 21st a previously unknown land was sighted. After describing the course of the navigation during February 18–20, Dr. von Drygalski proceeds as follows:†—

On February 21, at about 3.30 a.m., the announcement of land was made. After passing between many table-topped bergs, we found ourselves in front of a coast

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* See *Geographical Journal*, February, 1903. This map may be inserted either in the present volume, or at p. 220 of the *Journal* for February, 1903.

† What follows is a condensed translation of the original report.

entirely covered with ice, evidently the termination of an inland ice-sheet. The ice rises at first steeply and then more gently towards the south, and appears to cover a hilly land. Approaching the edge of the inland ice, we sounded, at a distance of 2½ miles, a depth of 219 fathoms. We then sailed westwards, taking magnetic observations and dredging. On the morning of the 22nd we found ourselves enclosed by heavy ice-blocks, in which we remained imprisoned till February 8, 1903.

Snow continued to fall with some intervals until February 25, when it was first possible to look around. The inland ice lay far to the south, and open water was seen in various directions, a wide lead being only half a mile distant. Attempts were made to release the ship, but it was embedded fast in blocks 16 to 20 feet thick and more, and when the snowstorm ceased, the temperature fell in the night to 14° Fahr., so that the mass of ice and snow was firmly frozen together. On March 1, the international term day, magnetic observations were made by Dr. Bidlingmaier in a hastily erected ice-house on a floe.

The winter station of the *Gauss* was, then, situated in pack-ice, and not close to the land. At first some doubts were entertained with regard to the branches of our work which demand a stable position for satisfactory execution; but these were soon allayed by the discovery that the mass of ice was perfectly firm, and remained so until January 30, 1903, that is, a few days before our release. Sometimes small variations were at first observed in the levels of the astronomical and magnetic instruments, and these recurred during the violent storms of winter. A slight rotation seems to have occurred of the whole mass of ice, which was afterwards fully determined; but in the course of the year it never amounted to more than half a degree, and continued slowly and steadily in the same direction. Otherwise the mass was as stable as land, and afforded the same conditions for scientific work, so that even pendulum observations could be carried out. The situation was more convenient for free movement than a land station, and the close connection with the sea which could be established at the ship itself or through the floe ice had advantages for the biological work, and indeed also for the magnetic and meteorological, which a station on land could not have afforded.

The great stability of the station was due to the formation of the sea-bottom above which it lay, and, secondly, to the easterly winds which prevailed almost to the exclusion of those from other quarters. The sea-bottom, 160 to 220 fathoms deep, ascended gently southwards to 100 fathoms at the edge of the inland ice 50 miles away, and was studded with banks on which icebergs were stranded. Such a bank, at a depth of 65 fathoms, lay to the west of the *Gauss*, and was covered with a number of stranded bergs which stretched in a continuous chain nearly 8 miles northwards, and then bent round sharply to the east, forming a bay in which we lay. Against this bank the pack-ice around the *Gauss* was driven by the easterly winds and storms and there stopped, so that till January 30, 1903, the currents running to and fro in the sea could effect no alteration. We had, moreover, a few miles south of us a compact ice-pack, which must have lain there more than a year, and some 19 miles further to the south still older packs with numerous groups of icebergs which had been a long time stationary. These and various other circumstances combined to give to our position that fixity it maintained throughout the year, though all the time there were leads in the ice 4 miles east of the *Gauss*, with floes drifting along them. The heavy and continuous snowstorms filled up the crevices between the blocks and fragments of icebergs, rendering them more easy to traverse. The whole complex lay in a great bay, the east coast of which was formed by the lofty inland ice we sighted on the morning of February 21, while on the coast it was bordered by a long tongue of floating ice,

which I shall have to refer to again, and will call the West Ice. I have called the newly discovered coast of the Antarctic land Kaiser William II. coast, and the great bay in which we lay Posadovski bay; while the bare volcanic peak which we found at its southern edge, at a height of 1200 feet, received the name of Gaussberg.

The installations of our scientific station were as follows: (1) Two magnetic observatories, of which one was set apart for the photographically registering variation apparatus, while the other served for absolute magnetic measurements. These were at first erected on a great floe about 350 yards south-west of the *Gauss*, and were built of ice-blocks, the first receiving a lining impervious to light. In the middle of June a removal became necessary, because the increasing snow-drifts pressed with exceptional force against these houses, and weighed down the floe more and more, so that the variation house was knee-deep in water. They were accordingly built anew in a small iceberg 250 yards south-south-east from the *Gauss*, and were kept in regular working order till January 30, 1903. (2) The meteorological station with all its accessories was erected about 40 yards south-south-east of the *Gauss*, but on January 10 was removed to another site east-north-east of the ship, as the hut in the first situation had melted away, and its position had become less accessible. (3) An astronomical observation hut of wood, erected for meridian observations, and also serving as a gravity observatory, was set up 200 yards west of the *Gauss*, encircled by a double series of sights, which also surrounded all the other installations of the station for the purpose of determining their displacements. (4) Two holes in the ice at the bow and stern of the *Gauss*, with blocks and windlasses to raise and lower the nets for biological work. From the beginning of January a fissure was generally used for this purpose, which had been opened 600 yards south of the *Gauss*. (5) An arrangement for tidal observations at the bow of the *Gauss*, consisting of a scale fixed to the jib-boom, which rose and fell with the tide, beside a pointer connected with the bottom 210 fathoms below by a wire heavily weighted. Apparatus was also fixed fore and aft to determine the direction and strength of the currents. (6) Two apparatuses for the measurement of the temperatures of the ice and sea by a combination of the electric and ordinary thermometric methods. One of these was placed on an iceberg fully half a mile from the ship, and reached down to a depth of 100 feet below its flat surface, the other on an ice-block, and then on the drift that accumulated over it from the stern of the vessel eastwards. The latter experienced many changes; at first it reached down to 30 feet below the surface—that is, below sea-level. Its lower parts sank beyond recovery in consequence of an enormous increase in the drift caused by a snowstorm in the middle of July, 1902, and was then kept working for some time at depths down to sea-level until in December it was extended down to 100 feet below sea-level. The smithy, kennel, magazines, etc., had frequently to be moved owing to the snow and the sinking of the ice under its weight.

The distribution of the work underwent many changes from the original plan, for the long-continued heavy snowstorms in winter added to the labour. This was particularly the case with the meteorological service, in which it proved impossible to keep the registering apparatus for temperature and humidity in order at all regularly, so that in May, 1902, I introduced hourly observations. The ship's officers were enlisted as assistants, being able easily to arrange their own duties so as to leave free time for this purpose.

The life of the members of the expedition was determined to a great extent, if not altogether, by the climate, for nowhere else on Earth do extremes of good and bad meet so closely as in Antarctica. The fine weather of the summer months would be suddenly interrupted by snowstorms, which made it impossible

to work, and almost to stay out-of-doors at all; but from the beginning of September to the end of April we could reckon on days generally clear and often fine, and make our plans accordingly. From the end of April to the end of August it was just the opposite. In these winter months one snowstorm followed closely on another, especially in May and August, choking up everything outside that was left unfinished, and burying the ship so that it had each time to be cleared again. In such weather all work outside the ship had to be left undone. The short rounds of the meteorological observers to record the hourly readings were very toilsome, especially with the lantern in the long dark winter, but the five men on whom it devolved always performed this duty with the same care. There were times, however, when it was quite impossible, and therefore for such cases special arrangements were made close to the ship for reading the thermometers. Those for recording ice-temperatures were deeply buried, and after the snowstorm had ceased were found again after a long search and set afresh. At these times the magnetic observatories had to be visited four times a day, and this Dr. Bildingmaier and his assistant L. Reuterskjöld did with self-denying devotion to duty, feeling their way along a cable. A cable was also laid to the astronomical hut, where the chronometers were compared once a day.

On March 29 three balloon ascents were made in fine clear weather by the leader of the expedition, the captain, and Dr. Philippi. From a height of 1600 feet a very instructive view over the surroundings and the position of the *Gauss* was obtained. The Gaussberg, discovered at the edge of the inland ice on the first sledge-journey that had been meanwhile accomplished by Dr. Philippi, second officer Valhsel, and the seaman Johanesen, appeared as the only spot free of ice, as the only conspicuous point in the neighbourhood. Thence the edge of the inland ice could be traced eastward and westward, the rows and groups of icebergs running out from it, the sheets of pack-ice, and the direction of the leads in it. This survey, obtained at a height of 1600 feet, was a guide in many of our subsequent undertakings. During the first two months of our imprisonment small excursions were often made from the *Gauss* to study the ice, erect geodetic marks, explore the neighbourhood, photograph, collect specimens of rock transported by the ice, to kill seals and penguins, and as holiday trips for the men. The ice at that season, the autumn of the southern hemisphere, being too rough, dogs and sledges were not used. Dogs were taken by the men simply as companions, but they were so delighted with their freedom that they went off by themselves, leaving on their way the traces of their murderous proclivities, so that it was necessary, for the protection of the penguins, to restrict their freedom by leashes.

It was particularly delightful in these excursions to observe animal life in its original state quite uninfluenced by contact with human beings. We met with two species of penguin, the small Adelia penguin and the Emperor penguin. The former we noticed on our way through the pack, and for a short time in autumn (February to March) at the station before the ice had quite come to rest, and again from November onwards when it began to get loose again. The Emperor penguins were less common in the pack, increased in numbers southwards towards the fixed ice, and were our constant companions at the station throughout the year. Both showed the same unsuspiciousness of man, and only on our return voyage through the pack were they at all shy of us. They differed, however, decidedly in temperament. While the small penguins hurried towards us full of life and movement, croaking, almost snarling like angry dogs, and barring our way as if ready to attack us, though merely acting in absolute innocence of danger, and many got among the dogs and lost their lives, the larger penguins made off slowly with philosophical composure. They stopped before strange objects, making

their presence known by trumpet-like tones or loud croaking, and only attempted to escape, if at all, when one stood close to them. Then they let themselves down on to the ice, and skimmed over it quickly, using their feet for propulsion, and steering with their wings. We noticed the small penguins only in small groups, while the larger ones passed by the ship in spring and autumn in flocks numbering as many as two hundred. We found especial pleasure in watching them in the leads, whence they would spring up on to the ice, and there continue on their way in a swimming posture. The spectator had need to take care that the birds, some of them as much as 75 lbs. in weight, did not strike him in springing out of the water.

The larger penguins were very useful to us as food, especially for the dogs. These consumed for some time three penguins a day. The skins and fat were burned, and so saved our fuel. The consumption of the expedition amounted in all to more than 500 penguins. Others fell a prey to our dogs.

We had seals—Weddell's seal—with us from October, 1902, in large numbers, and during our voyage through the pack saw leopard seals, chiefly at the outer edge, and further in towards the stationary pack the crab-eating seal—a distribution also confirmed on the home voyage. Seals were scarce in winter near the station. They were easily caught when they rested on the ice, and only raised their heads to stare with their large eyes at the approaching enemy, then calmly lying down again. In October they began to bring forth their young, and were then seen assembled on the ice with their young ones, though never in such large flocks as in the northern regions. The seals, too, were of great service to us. Their flesh, and especially the liver, was liked by every one, and was preferred to that of penguins, so that after October the latter almost ceased to appear on our table. The fat yielded good oil for illumination, and the skins were often used as clothing. Altogether we perhaps consumed 150 seals.

I shall not enter into details about the other forms of animal life, which were the special study of Prof. E. Vanhöffen. The bold and pugnacious skua gulls were constantly with us in autumn and spring; to hunt the greedy giant petrel, when it was too satiated with food to fly and could only run away, was a favourite sport. Of the characteristic petrels of the southern polar sea, the snowy petrel, in particular, wheeled round us in flocks with their rapid active flight at their nesting-place, the Gaussberg, while the other, *Thalassœca antarctica*, appeared there and near the ship in small groups. The small Wilson's petrel was common in the summer, and single specimens of the Cape pigeon were seen. Of the sea-fauna, besides seals, a species of Nototenia attracted general notice because it was so common in January and February, and was caught in bow-nets, so that we had very tasty meals; while another species of fish, a Lycodes, was only caught once, though its flavour, somewhat like that of eel, made the members of the expedition long for more.

The interval from the beginning of May to the beginning of September, the period of winter storms, and consequently of indoor occupation, may be considered the second period of our imprisonment. Our third sledge journey took place partly within its limits, and therefore was made under the least favourable circumstances. When we returned to the *Gauss* we found her prepared for the winter. A very important event during our absence before the middle of May was the discovery and repair of the leak. It was in the rudder well, and was discovered by sawdust thrown into the water. Then followed attempts to establish electric lighting. We had with us a small windmill, which, in connection with our accumulator, would maintain sixteen electric lamps. It was set up, and on July 3 the electric light for the first time illuminated the ship to general satisfaction. The wind, however, failed, and at the end of August oil lighting was introduced, every one being

furnished with a lamp. These lamps were of great service to us, and were used up to the time we left the ice in April, 1903.

Speaking of work outside the station, I may refer to a number of soundings taken by Captain Rufer during short sledge excursions of a day's duration, which gave us an insight into the configuration of the surrounding sea-floor. The short intervals of fine weather were also taken advantage of for the collection of rock specimens on icebergs, study of the icebergs themselves, for photographic surveys, etc. I may also mention the formation of a depôt, first on a floe, and then on an iceberg 2½ miles distant, as a precaution in case of ice-pressure and a consequent mishap to the *Gauss*. Otherwise our occupations were conducted indoors. We did not suffer from cold in the ship. The steam-heating apparatus was never brought into use, stoves burning anthracite being found sufficient. Social meetings were most successful during the winter storms—celebrations, lectures, discussions, music, games—in which officers, staff, and crew took part. The excellent state of health that prevailed among the members of the expedition contributed greatly to this result.

The third period of our life at the station gave us opportunities for longer sledge excursions. It began in September and ended at the beginning of December. The excursions involved the prolonged absence of several members of the expedition—eight at most. But no interruption was caused in the regular course of work at the station. Almost every day, except when there were snowstorms—and these became less frequent, though they did not cease altogether—individual members or parties made short excursions. Dr. Gazert and I spent these in measuring and examining the icebergs and floes in the neighbourhood, Dr. Gazert taking valuable photographs. Prof. Vanhöffen observed the seals, which appeared on the ice in greater numbers from October onwards, tending their young, and also the bird life, which increased in number and variety as the winter storms abated. Dr. Philippi collected the erratic rock detritus on the icebergs, and took some valuable photographs. Captain Rufer executed additional soundings, and other officers measured the thickness of the ice, and noted the changes in its position, and the opening out of fissures and leads. Movements occurred in the ice 4 miles east of the *Gauss*, and there were leads in it all through the winter, and 600 yards to the west a fissure had existed from the beginning of September. Otherwise the condition of the ice, except for trifling variations, remained the same till we were released on January 30, 1903. The light in spring was very good for photographic work, and Dr. Vanhöffen, Dr. Gazert, and Dr. Philippi obtained 308, 386, and 830 photographs respectively.

The fourth and last period of our stay at the station extended from the beginning of December, 1902, to February 8, 1903. The condition of the ice prevented us from going far from the ship, not so much because the ice was dangerous, as that its surface had become so disintegrated that one sank deep into it at every step. Then snow-shoes were brought out, especially the Norwegian *ski*. Sledging was continued for a time, the team being increased from seven to nine or eleven dogs, and short excursions were made till the ice began to break up on January 30. In December, pools were formed in the hollows between the snow-drifts and the inequalities of the ice, and here and there holes were sunk by melting right down to the water. In January they froze over, though thawing still proceeded below. Through these connections with the sea, seals appeared in all parts of the ice, and not only at the well-known fissures, so that our sportsmen found plenty of game close to the *Gauss*.

The work of the station was carried on without interruption till January 30, and was then stopped because the icebergs in the immediate neighbourhood began

to move. At this time the vessel was set in order ready for our departure, and works were started for the purpose of helping the ship out of its berth. A path of rubbish 10 or 12 yards broad was laid from the bow of the *Gauss* east and west over the ice in order to promote the thawing. It was 1¼ mile long, and ended on the east at a field of level ice where, as we perceived on our imprisonment, there was a frozen-over lead, and therefore an opening might be looked for; to the west it ended at a fissure which was formed at the beginning of September, and had gradually spread to 2 or 3 yards at the end of December. Ashes and refuse had been collected since June. At first much doubt was entertained as to its usefulness, but afterwards all agreed that the result was most satisfactory, and regretted that more had not been collected. However, enough refuse was dug out of the snow-drifts on the west side of the vessel to finish the path. Two to four men were constantly at work at it from the beginning of December. The effect was striking. The ice beneath melted away rapidly, and in January a steep-sided trench 6 feet deep was formed in the pack-ice, which was in parts filled with water and could float canoes. In some spots the whole mass was broken through, and seals and blocks of ice came up. In January the channel froze over, but the ice continued to melt beneath, and, at any rate, a line of small resistance had been formed, where finally the ice broke and we escaped. Still, this work was insufficient, for the pack-ice lay quite immovable, and only slight changes were observed at its outer border towards the east. As January drew to a close, the opinion spread that it would not break up at all, and indeed, considering the prevalence of easterly winds, could not break up.

We therefore began to dig out the *Gauss*, and first on the west side; but it proved an impossible task, as the drifts were fully 35 feet deep, and our work was rendered useless by a snowstorm. Then the east side was attacked, and from January 26 to February 7 the whole crew and officers worked hard, digging, sawing, and blasting, and excavated a hole by the middle of the ship 21 yards long and 6 broad. Ice 18 feet thick on an average had to be removed, and therefore the mass excavated amounted to about 1240 cubic feet. It was a great feat, but little in comparison to what must be accomplished if we were to get free. Calculate how we might, and taking into account all circumstances that might lighten the labour and accelerate the progress of the work, we could not estimate its duration at less than a year.

On February 8, 1903, we were relieved from our toil and set free. The increased power of the currents at full and new moon had, on January 30, enabled the icebergs around us to move northwards through the loose pack and to break it up. On February 2 we ourselves began to drift amid a pack 2½ miles long by 1¼ broad, which had separated in the west along the before-mentioned lead. We drifted with this pack a little to the east, a little to the north, and then back again among the icebergs we knew so well, some of which we knew to be stranded. The pack seemed unable to break its bounds. We had, however, frequently noticed movements of the ice within our pack caused by swells. On the morning of February 8 these were stronger than ever; sea-water forced its way through the fissures into our artificial channel and fell back again. The ice groaned and bent; it could not withstand this force. About midday an east wind again arose and threatened to drive us westward against the bank of icebergs and once more imprison us, but at about a quarter past three two short shocks were experienced, and we knew that the ice had broken. The dogs were quickly got on board, while the meteorological station and all the apparatus which still remained in the ice was packed up. By five o'clock the rift had so widened that the people on the ice had to be taken on board by means of ropes. The machinery was free, and at 7 p.m. (February 8,

1903) we left our winter quarters amid three hearty cheers, steaming along the lead which had opened towards the west, until, turning northward, we rounded the end of the bank of fixed bergs which had so long held us, and proceeded on our voyage.

Before describing the further course of the expedition, I propose to give a synopsis of the sledge-journeys undertaken from the *Gauss*. These were as follows:—

1. *March* 18–26, 1902.—Dr. Philippi, second officer Vahsel, and one seaman. Two sledges. Ascent of the Gaussberg. Photographs taken and geological specimens collected.

2. *April* 4–16, 1902.—Dr. Philippi, first officer Lerche, and seamen. Four sledges. Geological research on Gaussberg. Photographs taken. Ice-hut built at foot of mountain. Meteorological instruments set up there.

3. *April* 22 *to* May 15, 1902.—Prof. von Drygalski, Prof. Vanhöffen, Dr. Gazert, second officer Ott, and seamen. Four sledges. System of marks fixed and measured up on the land-ice near Gaussberg. Fishing, sounding, and dredging in the sea near the Gaussberg, and the edge of the land-ice. Meteorological and astronomical observations; zoological, botanical, and geological specimens collected. Photographs.

4. *September* 16 *to October* 14, 1902.—Prof. von Drygalski, Prof. Vanhöffen, Dr. Gazert, Dr. Bidlingmaier, second officer Vahsel, and seamen. Four sledges. Westerly route to Gaussberg. Further measuring of mark-system on land-ice. Supplementary measurement of Gaussberg. Photogrammetric work. Fishing, dredging, sounding. Supplementary astronomical observations, meteorological and magnetic observations, and photographic register of magnetic variations. Photographs. Record left in cairn on north-west declivity.

5. *October* 26 *to November* 5, 1902.—Dr. Philippi, first officer Lerche, and seamen. Two sledges. South-westerly route to ascertain trend of the edge of the land-ice westerly towards Gaussberg. Discovery of an ice-mass (West Ice) striking south to north; eastern edge followed south to neighbourhood of Gaussberg, and back to neighbourhood of its northern end.

6. *November* 18–24, 1902.—Dr. Bidlingmaier, Captain Rufer, second officer Ott, one seaman. Two sledges. Magnetic measurements west of winter station. Position of northern end of west ice ascertained. Soundings.

7. *December* 1–4, 1902.—Prof. von Drygalski, Dr. Gazert, Dr. Philippi, Captain Rufer, and seaman. Two sledges. West ice followed up to its northern end. Soundings.

Fifty-seven days were occupied by Prof. von Drygalski and Dr. Gazert in sledge expeditions, fifty-three by Dr. Vanhöffen, and lesser periods by other principals in the expedition.

It will appear from the foregoing table that the third and fourth journeys, made at a time when the winter storms were at hand, were protracted beyond the rest. The value of sledge journeys is manifest. New points of interest were discovered with regard to the continental relations of the south polar land-ice, an exact realization of south polar conditions from our position, etc. When I add that these journeys furnished an antidote to the unavoidable solitude of a sojourn in polar regions, it will be understood how much I appreciate the excellent equipment of our dog-teams, without which these journeys could not have been prosecuted. The land might have been reached without them, but lengthy journeys would have been impossible. Seven to nine dogs were used to each sledge; with seven, a burden of 670 lbs. could be dragged over difficult ice. The dogs were harnessed by pairs, with a leader in front. Where no track was obvious, one of us led the way. We lived and slept in tents and sleeping-bags, which afforded

sufficient protection from cold as severe as −30° C. (−22° Fahr.). Cooking was done with petroleum or naphtha; on the fourth journey we lost our fuel and had recourse to seal-blubber, and were forced to kill seals for use as food for men and dogs. The eight inmates of a tent were once confined to it for forty hours by a snowstorm.

On being freed from our winter quarters on February 8, 1903, our object was to investigate the coast region to the west. When we had passed the northern end of the ice-barrier, which had obstructed us so long, on the evening of February 8, we took a course, not easterly or north-easterly (which at first appeared the most direct), but northerly, with the intention of diverging to west when possible. My orders to the captain were to keep the best available course between north and west. Meanwhile, a gale which had sprung up at the moment of our release developed into a regular snowstorm, and on February 9 we were again beset in pack-ice. When it cleared, we found ourselves at the north-eastern end of the west ice. The time from now to March 16 was occupied in breaking a way through the pack with the engines, the captain taking every opportunity of progressing, first north-westerly, then more to the north and north-north-east through drift-ice. Sounding and other hydrographic work, with magnetic observations on the pack and on board, occupied us now, and afforded interesting results. A marked difference of climate was observed in comparison with the station we had occupied only a little further south. We had had easterly winds there, but west winds now reached us, and the weather was relatively warmer.

Our course had been along the northern edge of the west ice. On February 19 we lost it in 65° 32′ S., 87° 40′ E. (from Greenwich), having already passed the boundary between the shallow and the deep sea on February 16 in 65° 45′ S., 87° 57′ E. On that day we had soundings at 3 a.m. in 371 metres (203 fathoms); 10 a.m., 1103 metres (603 fathoms); 8 p.m., 1611 metres (880 fathoms). Here, then, there is a rapid fall from the Antarctic shelf.

Till February 20 we followed fairly long channels, covered already with young ice, in a westerly direction. After this channels through the pack were few, and progress was slow. On February 21 we met with an iceberg which we had previously marked; it demonstrated a westerly and somewhat northerly drift. The character of the pack was changing, and we were subjected to some wrenching and squeezing from the blocks. An increasing swell, moreover, hindered and finally prevented astronomical work on the pack. The ship behaved in every way satisfactorily, withstanding the ice and boring through it effectively. Our best screw, however, was broken off against an ice-block. The ice-*débris*, resulting from the collision of the floes, formed our most serious hindrance by stopping the momentum of the ship.

The time was now at hand when, a year previously, we had lain up in the ice. We were drifting northward, and were leaving the ice for clear water, and the question was, what next? The possibility that the ship would be overtaken by winter storms in loose pack-ice without a firm position opened up the possibility of dangers, and of having to remain under steam. For this our coal-supply would be insufficient. These and other reasons led some to advise our departure from the south polar regions.

In spite of this, I decided upon a further attempt southward. Our expected release took place on March 16, 1903, the pack being loosened, and we proceeded under steam. We steered at first north (March 14), then west (March 15), and reached the outer edge on the 16th, in 63° 52′ S., 83° 19′ E. The outer edge lay over 1° north of the position determined in February, 1874, by the *Challenger*. We followed the edge (seeing a few icebergs) at first west, then (March 17, afternoon) south, with an open sea before us. The water-temperature was remarkably

high. The dark grey albatross (*Phoebetria fuliginosa*) and other birds accompanied us, and suggested by their presence the existence of an ice-free sea to the south. On the evening of March 18, however, we were stopped by an ice-barrier. Next day came a storm from the west, and we ascertained that the open water was closing in. On March 20 we continued, first west, then south, progressing, with checks, through channels and leads till March 26. Scientific work occupied us during these checks.

It soon became clear that where we were, surrounded by icebergs (190 were counted in a day from the crow's nest), the sole protection to be derived from the firm freezing of the whole could not be counted upon. To proceed south was impossible, for the new ice could not be broken, and on all counts the position of the ship would be hazardous; the coal, moreover, would not last long enough. I gave the order to turn on April 8 about midday, and it was carried out in 64° 58′ S., and 79° 33′ E. It may be safely asserted that we should have been in the same predicament at only a few minutes of latitude north of our winter quarters. This shows once more how nearly extremes meet in the south polar region. The influence of the wide girdle of ocean with its westerly storms and heavy swells extends across two degrees of heavy pack-ice to the near neighbourhood of the fixed inland ice amid the shallows of the continental shelf, keeping the ice in a constant state of unrest. The steady ice-conditions which we had at our winter quarters, and to which alone we owed the possibility of carrying out our scientific observations there in their entirety, depended principally on the easterly storms, together with the climatic influences of the inland ice and stranded icebergs. Such conditions would probably be constantly repeated at the spot in question, and might even last throughout the year, as there are shoals on which some, at least, of the bergs that break from the edge of the inland ice must be stranded.

On April 9 we got clear of the ice. The storm-tossed blocks through which we passed made a magnificent picture. The boundary of the pack-ice east of us trended northward, so that till the evening of April 10 the ice-blink was visible. We struck single blocks of ice on the 10th. To west we saw no sign of pack-ice. The sea-temperature on leaving the ice in 64° 38′ S. and 79° 47′ E., as usual, rose rapidly. Magnetic and oceanographic work was done on the way home, but the deep-sea dredge could not be used owing to stormy weather. On April 13, in 59° 54′ S., 70° 22′ E., the last iceberg was passed. Kerguelen island was passed on the 19th, St. Paul on the 26th, New Amsterdam on the 27th. Between April 30 and May 3 we passed from the roaring forties into the calms, and entered the trades on May 3. On May 11 two ships were seen, and the second was spoken and a message sent to the German consul at Delagoa bay. Port Natal was reached on May 31, and on June 9 the harbour of Simons-town, in False bay.

REVIEWS.

EUROPE.

North-West Europe.

Stanford's 'Compendium of Geography: Europe.' Vol. ii. Edited by G. G. Chisholm. London: Stanford. 1902.

In the new issue of this series, the second volume of *Europe* is devoted largely to an elaborate treatment of the British Isles. The whole volume (without reckoning index) contains 720 pages: of these 580 are occupied with England, Scotland,

and Ireland. The treatment is throughout interesting, vigorous, thoughtful, and minute; but is somewhat out of proportion to the rest of Europe. In particular, chapters xi–xiv., on Early Inhabitants of Britain, on Roman Britain, on The Teutonic Settlements in Britain, on The Effects of the Teutonic Settlements, on The Norman Conquest and its Results, though each and all of high excellence in themselves, are of a character very different from what is anywhere to be found under the other lands of our continent. Elsewhere the historical details given are mostly incidental to the description of the towns. The minuteness, also, with which the past conditions and phases of British trade are reviewed, and contrasted with the present, is quite unlike what we find in the treatment of other European regions in this series. Thus chapters xvi.–xxii., on The Population of England—Domesday to 1800,—and on English Agriculture, Mining and Smelting, Manufactures, Foreign Commerce and Shipping, and Political Situation during the same period, from the eleventh century to the close of the eighteenth, together with the elaborate survey of England in the Nineteenth Century, may be called unique in this series. Nothing really parallel to it is even attempted elsewhere; nor could it have been without swelling the Compendium to unwieldy size. Very high praise must at the same time be given to much of the matter in these portions of Mr. Chisholm's work: one only wishes, at times, that he would quote less and give his opinions more; for (as on pp. 274, 275, in his discussion of English population under William the Conqueror) these opinions are admirably sane and avoid the falsehood of extremes very happily. In the account of Ireland sufficient direct attention does not seem to be given to the American emigration of the Irish race, and to the steady drain upon the prosperity of the Green Isle which this involves, causing, in spite of every measure to the contrary, a continuous and still existent decline in the population of the country as a whole, and an unarrested decay in many of its industries. Unstinted praise must be given to the care and zeal with which Mr. Chisholm has undertaken what is really a separate treatise, involving a great mass of work, upon his own country; and especial value attaches to the statistical parts of this treatise. C. R. B.

History of Falmouth.

'Old Falmouth. The Story of the Town from the Days of the Killigrews to the Earliest Part of the Nineteenth Century.' By Susan E. Gay. London: Headley Brothers. 1903.

The title sufficiently explains the scope of this book, which contains a large mass of interesting information on the fortunes of Falmouth through the most stirring days of its history. Although lacking the antiquity of some of our more famous towns, the story of Falmouth has a charm of its own, and supplies an interesting object-lesson of the vicissitudes brought about by the changing conditions of different times. The early history of the site centres in the Manor of Arwenack, which came into the hands of the Killigrew family (previously landholders elsewhere in Cornwall) through the marriage of Simon Killigrew to a daughter of the Lord of Arwenack towards the end of the fourteenth century. It was through the efforts of a later member of the family, who had entertained Sir Walter Raleigh in his castle on his return from Guiana, and found in him a cordial supporter of his proposal to utilize the great natural advantages of the site, that the permission of King James I. for the development of the town was obtained. But the palmy days of the place were those of the Postal Packet Service, of the stirring history of which, and the daring exploits of the captains engaged in it, Miss Gay has much to tell. The modern decline of the place as a port of call (though its graving

docks offer unusual facilities for repairs to the largest vessels) has been due to the advent of steam-navigation, which encouraged the great liners to make use of the short cut across the bay to Plymouth. The future prospects of the place lie in its development as a health-resort, in which respect it possesses many of the advantages of the more fashionable resorts further afield. But Miss Gay makes a well-justified protest against the prospective ruining of its natural beauties by the vandalism of the modern builder.

Some notes are given on the earliest maps of Falmouth, one of which, drawn in the reign of Henry VIII., is reproduced in facsimile. There are also many illustrations of the old architectural objects of the place, and portraits of its most distinguished worthies, including members of the old quaker family of Fox.

ASIA.

SIBERIA.

'Greater Russia.' By Wirt. Gerrare. London: Heinemann, 1902.

This is a new book, and a useful one, added to the now considerable library of modern works on Siberia, the Amur, and Manchuria. The style is, it must be confessed, rather flat and stale, but the matter is not unprofitable. The arrangement of the narrative, and of the author's remarks and discussions, is sometimes wanting in clearness, in logical precision, and in that brevity which is the soul of wit: there are occasional repetitions of a needless character. But a mass of detail is given us which is obviously—and professedly—from first-hand observation, which is often very interesting and suggestive, and which receives great assistance from a series of excellent illustrations. The chief addition Mr. Gerrare makes to previous Western knowledge is in his account of a new Russian railway in Mongolia. This branches off from the main Siberian-Manchurian line about 70 miles west of Khailar and about 650 miles north of Pekin, and thence drops down southward towards Kalgan and the Great Wall of China along the western slopes of the Greater Khingan range, running almost due south at first, south-south-west later. It skirts the eastern side of Dalai-Nor and Buin-Nor lakes, and is intended (according to the information collected by the author while travelling in disguise through Manchuria) to follow the old Mongol trade-route from the Khalkha river to Dolon-Nor and Kalgan. It is a substitute for the Kiakhta-Kalgan railway scheme —across the Goti desert—and is said to have been suggested to the Russian authorities, partly by their own travellers and surveyors, partly by Scandinavian missionaries flying before the "Boxers" and taking refuge within the Russian lines. Only a small part of the new branch was finished when Mr. Gerrare passed along the trunk line to the north, but if it has been pressed forward with the same speed as the other parts of railway construction in Russian Asia, it may well by this time have reached within measurable distance of Kalgan. If so, its importance will be obvious: strategically, it would clearly be, when completed, the most important part of the whole Siberian system.

In Greater Russia, the author, while criticizing freely and sharply, speaks on the whole with well-balanced approval of recent developments. Certainly there has been a marked improvement since the old *régime*, the time of Nicolas I., or even that of Alexander II.; and the improvement has affected both sides of the Urals, though not equally. "There has been a great awakening of Russia. The people, debarred generally from active participation in politics, have directed their energies towards the commercial and industrial exploitation of their native land." In particular, "the Siberia opened by the railway is a land of much promise," and especially promising

are the newer settlements along the line, neat railway buildings, immigration homes, schools, churches, mills, stores, substantial and commodious dwellings of all sorts, typical of the free colonies which the Russian Government has of late been planting so assiduously. In the exact phrase used by J. Y. Simpson, in his 'Side Lights on Siberia,' Mr. Gerrare concludes that Russia seems to be "developing faster than any other European nation," and notes the Russian passion for the most recent American inventions, co-existing, however, with an extreme backwardness and a blind conservatism in many parts and on many sides of life, and especially of agricultural life. C. R. B.

AFRICA.

Tripoli.

'A travers la Tripolitaine.' Par H. M. de Mathuisieulx. Paris: Hachette. 1903.

The modern literature on Tripoli is so scanty that even this unpretentious little work, written by a traveller who was accorded unusual facilities for penetrating the interior, is a welcome addition to our knowledge of that country, although the preface by M. Bertrand perhaps exaggerates somewhat the general inaccessibility of the vilayet to Europeans. Much as the authorities are averse to permitting the free passage of travellers beyond the walls of the capital, more than one recent traveller has succeeded in gaining some first-hand knowledge of the country, which towards the middle of the nineteenth century was still more accessible to the outside world. The early chapters of the book give a graphic description of the city of Tripoli, its antiquities, its motley inhabitants, and its relations with the far south by the caravan-route across the Sahara; but more novelty is perhaps presented by the account of the author's two circular tours in the interior, in the course of which he visited the Gariana and Yiffren uplands to the west, and the plateau of Tarunha and the Msellata mountains to the east, of the centre line of the country. The whole of this mountainous zone falls steeply to the north in an escarpment broken by numerous wadis, while to the south it falls gradually, in accordance with the dip of the strata, to the stony deserts of the Hammada el Homra. As the northern outliers of this elevated zone show a reversed dip, the author suggests that the original line of the water-parting ran nearer to the sea, and has been pushed back by the effects of erosion. The scattered Berber population of the Tripolitan "Jebel" has lost all its old love of freedom, and the whole country is under the effective occupation of the Turks.

M. de Mathiusieulx draws a melancholy picture of the poverty and desolation of the country, and considers as a mere delusion the idea that—apart from Barka—any great amelioration of its agricultural capabilities is possible. He considers that the present state of things is due to the destruction of the forests, which, in his opinion, once covered the mountains, though it may be doubted whether the evidence is such as to justify this conclusion. He has much to say on the most interesting antiquarian remains which are scattered so thickly over much of the country, some of which he was able to bring to light for the first time. Various examples of these are to be found among the author's photographs, which also give a good idea of the general surface features of the country.

Adventures in British East Africa.

'An Ivory Trader in North Kenia.' By A. Arkell-Hardwick, F.R.G.S. London: Longmans. 1903.

Although largely concerned with sporting adventure, this book acquires a further interest from the fact that it deals with a country still beyond the outskirts

of civilization, and to which but a few travellers had previously penetrated. The author belongs to the class of young and adventurous Englishmen who did so much in the early pioneering days to extend the bounds of geographical knowledge, though with the greater demands made on the traveller by modern scientific methods such journeys must now take a more or less subordinate place in the scale of merit. Without possessing the scientific training which would enable him to give a systematic account of the geography of the districts visited, he shows himself an observer of some acuteness, and had he lived some half-century earlier, he would probably have taken a high place among the adventurous spirits who rolled back the curtain of mystery which then covered the interior of Africa.

Mr. Hardwick, who had previously led a more or less wandering life, and had gained experience with the British South African Police in Mashonaland, went to East Africa in 1899, and in course of time joined two other Englishman, one a hunter of much experience, whom he names throughout "El Hakim," on an expedition to the north-east of Mount Kenya, along the course of the Gwaso or Waso Nyiro. It will be remembered that this stream was traced by Chanler almost to its supposed termination in the Lorian swamp. On reaching his furthest point, however, after many difficulties owing to the desert nature of the country, no trace of Lorian was visible, and though the Gwaso Nyiro was followed for some distance further, its end was not reached. Mr. Hardwick thinks that the swamp seen by Chanler must have been the highest of a series, most of which had since dried up owing to the three years' drought to which the country had been subject. He draws a striking picture of the desolation which characterized the region on this account; travelling over the loose brown soil, varied occasionally with lava-blocks, being excessively fatiguing to the traveller. The country produced a superabundance of rhinoceros, which caused constant alarms to the caravan, but apparently little else. Mr. Hardwick and his friends made the acquaintance of a section of the Rendile Gallas, who are still little known to geographers. He was agreeably impressed with their physique and cleanliness, as compared with the other races with which he had come in contact, and gained a more favourable impression of them generally than had been done by Chanler. The Burkeneji, another tribe met with on the Gwaso Nyiro, are more akin to the Masai, whose propensities they share to a great extent. The caravan eventually made the complete circuit of Kenya, thus passing through other little-known districts; and Mr. Hardwick's descriptions of the country are a considerable help to an understanding of its characteristic features.

THE MONTHLY RECORD.

EUROPE.

The Schilling-See in East Prussia.—Herr G. Braun of Königsberg, who is engaged in the preparation of an important work on the lakes of East Prussia, has lately carried out soundings of some of the lakes, as to whose contours little was previously known. He gives the results as regards the Schilling-See in the third number of *Petermanns Mitteilungen* for the present year. The lake lies on the elevated western part of the Prussian ridge known as the "Oberland," and originally belonged to the system of the Drewentz, but, like a whole series of the Prussian lakes, its hydrographical relations have been artificially modified by the making of the "Oberländische Canal." The lakes of this series may be divided according to

their depths into two main groups lying east and west of each other. Those to the east are generally deep and markedly furrow-like, while the western lakes are shallow and round in outline. Still further east is another group not connected with the canal. The Schilling-See is one of the furrow-shaped group, of which it may be considered thoroughly typical. With others it lies on a line of depression, running somewhat west of north-west (the normal direction of the long narrow lakes of its class), the land-contours between the separate lakes continuing the valley-like form of the parts covered by water. The lakes of this class occupy troughs eroded by the glacial water beneath or in front of the ice-mass, while the wide shallow lakes are ground-moraine lakes. The land-contours drawn on Herr Braun's map bring out clearly the (at first sight) somewhat singular fact, which is explained, however, by the glacial history of the region, that the lake crosses at right angles the depression, little above sea-level, through which the Oberländische canal passes, both its north and south ends being bordered by comparatively high ground. One of the main deep basins—in fact, the most extensive of all—lies athwart the line of lower ground. This exceeds the depth of 100 feet for a length of over a mile. From a series of temperatures, taken by Herr Braun on August 22, 1902, the sudden fall of temperature takes place between 11 and 12 metres (36 and 39 feet). The surroundings of the lake are marked by seclusion and the general absence of human activity, timber being the only product calculated to call it forth. This clothes the steep shores of the northern end, while those to the south are in strong contrast from their bareness. Herr Braun gives some description also of the Narien-See, one of the group of ground-moraine lakes, former soundings of which were confirmed by his own work.

ASIA.

Investigations in Sistan.—Mr. G. P. Tate, of the Indian Survey department, whose previous work in the western borderlands of India is well known to our readers, sends us, under date May 30, 1903, an interesting account of investigations made in Sistan during the stay of the British boundary commission in that region. Owing to drought in Afghanistan, the lower Helmund, and with it the Hamun-i-Sistan, had quite dried up in the summer of 1902, causing all the fish, as well as the herds of wild pig and numbers of the water-fowl, to perish. The ruins of the old city called Shahr-i-Sabari, which are usually covered with water, were exposed to view. They consist of the foundations of houses, all constructed of baked brick, and covering a large area. Copper coins and other curios were obtained from them. Mr. Tate was able to study the floor of the lake, the configuration of which is of much interest. It consists of a series of shallow pan-like hollows, with low ridges between, but connected with each other by narrow channels. The ridges are covered with water in a normal season, but even then admit of the crossing of the Hamun by wading. Levels taken on the dry bed of the lake showed an upward inclination towards the west and south. The Helmund began to rise on March 1, and the lake had since been gradually filling, the water entering almost entirely by the Rud-i-Perian, which, as the Siksar branch will soon be quite abandoned, promises to become the main and only branch of the river. (For the various changes of the course of the Helmund, cf. Major Sykes's paper in vol. xix. p. 143.) When the Rud-i-Perian silts up, Mr. Tate thinks that the river will revert to its ancient bed under the cliffs of the Dasht-i-Marp and the district of Sar-o-Tar to the east. The Hamun fills up from the east and north, the water gradually spreading south into the Sasela river and the Gaud-i-Zirreh, a circumstance which bears out the results of the levelling. At the end of April it was possible to ride across the Hamun, with practically no water on the way, but on the return on May

8, the crossing was effected on rafts of bulrushes, the camels wading. A current of 2½ miles an hour was then setting south. Both the Farah Rud and the Khash Rud (north and east of the Hamun) were also in flood, and helped to fill the depression. At the embouchure of the latter a large area is flooded around Chakansur, producing rich pasture after the floods have dried. It is called Ashkinak. This term (or "Ashkin") is generally applied to lands only temporarily flooded; "Chung" to water too deep for reeds to grow; "Naizar" to shallows and reed-beds; and "Hamun" to a large expanse free from reeds, such as the lake itself. Mr. Tate says that modern improvements and methods now in use in the Indian Irrigation Service, such as syphon bridges, were employed in olden times in Sistan. The heads of the distributing channels, etc., were of baked brick set in cement, and the old canals have masonry abutments, on which rested wooded bridges. Many interesting remains are to be met with in the Sar-o-Tar district, where are the sites of towns, fortresses, and villages which yield quantities of Sassanian, Parthian, and Scythian coins, as well as those of the Caliphate and later Mohammedan dynasties. Mr. Tate is making an archæological survey of the ancient towns and sites, illustrating these by photographs, which should prove of much interest. He hopes to continue his work during the present summer. We are also informed by Major H. F. Walters that, during the stay of the Commission in Sistan, the altitude of the Kuh-i-Khwaja was independently fixed by two of the officers, the result being to place it at 2037 feet above the sea, or 437 feet above the plain. This agrees well with Major Sykes's estimate of 400 feet.

Stone Figures in China.—Under date "Hsiaochang *viâ* Te Chou, Tientsin, North China, April 27, 1903," Dr. Sewell S. McFarlane sends the following communication: "In February, during one of my journeys in the south-west province of Chili, North China, I came across a number of stone horses, sheep, lions, etc., some in a fair state of preservation. They were in two parallel rows, and beside them were

STONE FIGURES IN CHINA.

several 'petrified' Buddhist priests, supposed to be on guard. The people seemed to know nothing about them, and cared less. Upon inquiry among the gentry of the adjoining village, one old gentleman informed me that it was the entrance to a very old subterranean tomb, of one of China's prime ministers who lived under the Han Dynasty. This would be about the year A.D. 25. Many years ago a tablet stood there, which they unearthed with the above stone figures, giving full particulars, but the disinterested inhabitants destroyed it, 'as it was in way of their cart track.' How the people came to unearth these huge statues is interesting. During the past generations, the severe dust-storms experienced in North China have swept over the district and steadily but effectually buried out of sight the beautiful tomb and all its accompaniments. The inhabitants frequently dig out their land to make mud bricks for their houses, and in this manner the stone figures came to light. It is said there are a great many more of them, ere one reaches the actual tomb. Had this been in England, these ancient curios would have been excavated and a correct description published centuries ago. But in China the country folk, who simply live from hand to mouth, somewhat take after Gallio, of sacred writ, and 'care for none of these things.' I enclose a snapshot of part of the excavated avenue, hoping it may be of interest to the readers of our good old *Journal*."

French Survey of the Upper Yangtse.—We announced, early last year, that Lieut. Hourst, previously known for his excellent work on the Niger, had ascended the Yangtse rapids in a gunboat with a view to carrying out a survey of the upper river. Since that time M. Hourst and his coadjutors have been actively employed in this work, and the results, which are summarized by M. Bons d'Anty in the May number of *La Géographie*, promise to be of much value for the navigation of the river and our exact knowledge of its upper basin, though a certain amount had already been done in this direction by the British officers in command of the gunboats which ascended the river two or three years ago. The precision of the river survey seems to have varied to a certain extent in different sections. Between Ichang and Chungking (395 nautical miles), and between Chungking and Swifu (230 nautical miles), a careful triangulation was carried out by means of the theodolite, the detail of the banks being filled in by the plane-table, while careful soundings were made, including three continuous lines in the upper section. Between Swifu and Ping-shan-hsien the survey was carried out by compass and plane-table, and above the latter a rapid examination of the stream was made as far as Shen-niu-tan, this section being quite impassable by steamers. Other surveys were carried out on the small river Kiangwo-ho, on the Min between Swifu and Kiating (with reconnaissance beyond Kiating to Kiang-kiu), and on the Fu-ho which joins the Yangtse at Fu-chou. The chief work remaining to be done was the examination of the Kialing-kiang, which joins the Yangtse at Chungking. It may be mentioned that the Yangtse was this spring ascended to Hankow by the *Glory*, the flagship of the British China squadron, this being the first battleship and the largest vessel that has yet reached that port.

AFRICA.

The Geological History of the Sahara.—Some two years ago, it will be remembered, considerable interest was aroused by communications from M. de Lapparent, urging the necessity for a revision of our ideas with regard to the geological history of the Sahara, in view of the evidence supplied by a fossil sea-urchin from Bilma, which he had had the good fortune to bring to light, that in Cretaceous times the sea must have covered the region around Lake Chad. Some hesitation was naturally felt in accepting without reserve a conclusion of such

importance on the authority of a single fossil, which might conceivably have reached Bilma by the caravan route from Tripoli. But M. de Lapparent has used his influence to secure the collection of further evidence by some of the many French officers at work in the Central Sudan, and his efforts have already met with decided success. As related in the June number of *La Géographie* (in which journal, as well as in the *Comptes Rendus* of the Paris Academy of Sciences, the subject was originally broached), a further discovery of fossils has been made by Captain Gaden, an officer to whom the search for such evidence was suggested by Commandant Gourand, in the vicinity of the Anglo-French frontier to the north of Sokoto. At a place called Tamaske, some 250 miles west of Zinder, there is a horizontal bed of limestone, cut up by the *dallols*, or old river-beds, which characterize the region. In the side of one of these Captain Gaden found fossils, which he sent to M. de Lapparent. They proved to be a nautilus and four sea-urchins, the latter of which, when examined by M. Victor Gauthier, showed that the deposit was of marine origin and of the same age as the limestone of the Paris basin, which was laid down in the old "Lutetian" (Tertiary) sea. It is reported by Captain Gaden that similar fossils occur in the region extending from Zinder towards Air, and as the country between this and Lake Chad is quite level, M. de Lapparent justly concludes that the Lutetian sea reached the position of the lake, and probably of Bilma also. But this is not all, for sea-urchins, not absolutely identical, but of the same age, have recently been found near Dakar, and in spite of the considerable distance which intervenes, M. de Lapparent holds that an arm of the sea must have extended inland from the Atlantic to the Eastern Sahara. He points out, also, that the Indian affinities of the sea-urchin from Bilma, and the fact that those lately found at Tamaske belong to a genus known hitherto only from India and Egypt, point to an unbroken sea-communication between India and the Central Sahara by way of Egypt, in Cretaceous and Tertiary times. Northern Africa would then have consisted merely of two large islands, the one formed by the massifs of Air, the Tassili, Ahaggar, and Twat, the other (possibly a peninsula) by the Abyssinian highlands. M. de Lapparent has certainly shown that existing ideas as to the geological age of northern Africa as a whole must be seriously reconsidered.

Journey in the Western Sahara.—It is announced in the *Politique Coloniale* for July 20-21 that Colonel Laperrine, whose name is well known to geographers for his survey work in the Algerian Sahara, has made an important journey to the south from Timimun, pushing into the desert to a point some 250 miles from Twat, and nearly halfway between that district and Timbuktu. Over 500 miles of new routes are said to have been surveyed.

The Islands of Lake Chad.—Reference was made in the *Journal* for June of this year (p. 674) to the valuable work lately done in Lake Chad under the orders of Colonel Destenave. The map of the eastern part of the lake, which has been prepared by Captain Bézu from the observations of the various officers employed, is given in the June number of *La Géographie*, and brings out admirably the remarkable character of the eastern coast region. As already mentioned, the islands which fringe this coast run with great regularity from north-west to south-east, this being due to the currents and prevailing winds. Another point clearly brought out by the map is the great regularity in their distribution. Never does the mainland touch the open water throughout the whole eastern side of the lake, though the width of the zone of islands varies from about 5 to nearly 20 miles. The intervening channels show great uniformity in width, rarely much exceeding 2 miles, though in places they are much narrower. The map distinguishes by colours the low-lying islands and sandbanks from those occupied by forests or plantations. The actual shore of the lake is very ill defined, as it is

much cut up into peninsulas which reproduce the trend of the islands. In a brief description of the work of the survey, Colonel Destenave gives some interesting details regarding the general hydrography of the lake. In the deep south-west basin its waters are yellowish, no doubt owing to the existence of banks of clay. In the region of the islands and in the extreme north they are often muddy, though much clearer around sandy islands. At the time of its annual rise the water is sweet and limpid, and only at low water (May and June) is it at all brackish. According to Captain Dubois, the numerous lagoons round its shores act, like the gulf of Karaboghaz in the Caspian, as purifying pans in which the greater part of the salts contained in the water is precipitated during the fall of the lake. High water occurs in December, the rise amounting to 1·20 m. (4 feet) only. There is likewise a general displacement of the water-covered area towards the west. From the Shari delta to the eastern corner of the lake, a distinct current runs along the south coast, and is known to the natives, like the depression which runs to the east from this neighbourhood, as the Bahr-el-Ghazal. At the time of the great rise noted by Nachtigal, there is said to have been also a water-communication between the Bahr-el-Ghazal and Gulfei on the Shari, and as Colonel Destenave speaks of the former *mouth* of the Bahr-el-Ghazal, it would seem that some of the Shari water formerly made its way to the lake by this route.

M. Duchesne-Fournet's Expedition to Abyssinia.—M. Duchesne-Fournet, to whose expedition to Abyssinia reference has already been made in the *Journal*, has returned to France, and gave an account of his journey at a meeting of the Paris Geographical Society in April last, an abstract being printed (with sketch-map) in the May number of *La Géographie* (pp. 392–395). Although the route traversed little absolutely new ground, the journey appears to have contributed materially to a better mapping of some of the less-frequented provinces of Abyssinia, careful surveys having been executed with the theodolite, with the aid of Lieut. Collat and others of M. Fournet's companions. From Addis Abbaba the expedition went north across the plateaus which separate the capital from the deep cañon of the Blue Nile, which was crossed into Gojam. The capital of this province, which has now been brought under Menelek's direct rule, at present goes by the name of Markos. It formerly bore the name of Monkorer. The expedition traversed Gojam in various directions, visited the source of the Blue Nile (erroneously stated to have been "discovered" by D'Abbadie), executed a survey of Lake Tana, and returned south across the highest part of the Choke range, on which abundant vegetation was found up to a height of over 13,000 feet. The Blue Nile was crossed further west than on the outward journey, and the route continued through the Kuttai district on the south bank, said to have been previously unexplored, though it must have been approached very closely by Neumann. M. Fournet subsequently visited the province of Wallaga.

The Macmillan Expedition to the Blue Nile.—News has just arrived of the failure of the well-equipped expedition under Mr. W. N. Macmillan, an American, to descend the Blue Nile from the Abyssinian highlands to the plains of the Sudan. The expedition was provided with iron punts, in which it started down the river on June 26, but, according to a Reuter telegram from Aden on July 22, two of the punts, which contained a large proportion of the stores, were lost during the passage of the rapids, the occupants swimming ashore, but suffering further loss from a hurricane which swept the gorge during their enforced detention on the river-bank. The expedition was compelled to return to Addis Abbaba, and for the present, at least, the attempt has been abandoned.

Commander Whitehouse's Survey of the Victoria Nyanza.—Commander Whitehouse, who a few years ago executed a survey of the northern shores of the

Victoria Nyanza within the British sphere, has lately been engaged, by agreement with the German authorities, on a survey of the southern half of the lake in the interests of the steam-navigation of its waters. The steamer *Winifred*, which was lately placed on the lake, has completed a circumnavigation, and a regular service between its various shores is contemplated. If this be established, the quickest route to Tanganyika will probably be by the Uganda railway and the Victoria lake.

The Position of Bohodle, Somaliland.—The British field force in Somaliland is accompanied by an officer of the Indian Survey Department, who, as we are informed by the Foreign Office, has made an exact determination of the position of the advanced base at Bohodle, or Bohotle. The co-ordinates thus fixed are lat. 8° 14′ 43″·1 N., long. 46° 20′ 18″·5 E., the position thus obtained being considerably to the west of the supposed position, though the place still remains within the British boundary.

AMERICA.

Exploration and Mining in the Copper River Basin.—The United States Government is continuing its efforts to develop the mining district of the Copper river. The military trail from Valdes over the Thomson pass (see vol. xix. p. 611) was completed in 1900 as far as Taslina river; the Klutina river has been bridged, and ferries established on the other principal tributaries. The geology and mineral resources of parts of the basin are described by Messrs. Schrader and Spencer in a publication of the Geological Survey. The oldest rocks are metamorphic, divided into three series, named the Klutina, Valdes, and Orca, all of which are traversed by intrusions of igneous rocks of a later date than that of the latest intense folding. After the Orca series had been metamorphosed, the region was deeply eroded, the land sank, and three series of beds were deposited—the Chitistone limestone of Carboniferous age, Triassic limestones and shales, and the Kennicott formation of late Jurassic or early Cretaceous age, the last lying unconformably on the upturned edges of the other two. Below the Chitistone limestone lies the Nicolai greenstone, a series of volcanic flows which form an important mass in the Wrangell district. With this are associated all the copper deposits of the basin—the Nicolai mine towards the White river, the Bonanza claim near McCarthy creek, and the deposits on the Kotsina, Kuskulana, and Chitina rivers. A sample from the Bonanza claim yielded over 70 per cent. of copper, some silver, and a trace of gold. Several claims have also been located on the shores and islands of Prince William sound. Quartz gold is known only at McKinley lake, on the north side of the Copper delta. Of placer mines, the most promising are those of the Chestochina river. The gold seems to have travelled for some distance, but the fragments of schist and quartz which frequently cling to it show its origin from vein deposits. Engineers regard the Valdes route as practicable for the construction of a railway to the Copper river. A branch would then be carried to the Kotsina and Chitina copper districts, and eventually the line might be extended by way of Mentasta pass to Eagle city. Regarding the occurrence of coal in the Copper basin, nothing definite is known at present. In other parts of Alaska, however, coalfields have been discovered. Mr. John Kirsopp, junior, gave details of several seams of lignite in Cook inlet and on the Sushitna river before the Institution of Mining Engineers in 1901. He also described the Chilcat coalfield, and those of south-eastern Alaska, Vancouver, and British Columbia. The coal of Queen Charlotte island compares very favourably with that of other Pacific coalfields, and, as the limited area of coal-seams in Vancouver is being rapidly exhausted, Queen Charlotte coal will probably soon be placed on the market.

Alaskan Survey Programme for 1903.—The work of surveying and

mapping the mining region of Alaska will, we learn from the June number of the *National Geographic Magazine*, continue to be actively prosecuted during the present summer. The districts to which special attention will be devoted will be the Seward peninsula, Yukon and Tanana goldfields, and the Kayak island and Controller bay petroleum and coal fields. The mining districts of south-east Alaska will also be examined.

New Survey of the Colorado Cañon.—According to a note in the *National Geographic Magazine* for April last, a re-survey of the Grand Cañon of the Colorado has lately been carried out for the U.S. Geological Survey by Mr. F. E. Matthes. The new map, which is to embody the results of this survey, will be on the scale of one mile to the inch, with contours 50 feet apart, and will show all the topographical features in true proportion. The average width of the cañon from rim to rim is stated to be less than 10 miles at its widest, and to be frequently as little as 8 miles. On the south side the depth is under a mile, but from the more elevated north rim the drop averages considerably over a mile, and in many places exceeds 6000 feet.

The Degree Measurement in Ecuador.—The report by M. Poincaré to the Paris Academy of Sciences on the work carried out in 1902 by the French expedition for the remeasurement of an arc of the meridian in Ecuador, is printed in the *Comptes Rendus* for April 6 in the present year. While regretting that unfavourable weather conditions and other obstacles have retarded the progress of the work so that it is now some six months behind the calculated programme, M. Poincaré announces that the results are so far eminently satisfactory, the highest degree of accuracy having been maintained throughout. The measurement of angles had been rendered exceedingly difficult by the unusual amount of mist and clouds in which the summits were enveloped, and which hindered all work for days together. The preliminary reconnaissance had given no indication of such a state of things, and it is suggested that the volcanic disturbances, which seem to have spread last year from the West Indies to the Cordillera, may have had some influence on the meteorological conditions. Another difficulty arose from the interference with the signals, both by the native Indians and by the whites, which every effort seemed powerless to prevent, and which sometimes involved the repetition of whole sections of the work. In the previous season (cf. *Journal*, vol. xx. p. 343) two bases had been measured—the one in the neighbourhood of Riobamba, carried out both with the bimetallic bar and with the Jäderin apparatus; the other in the north, at El Vinculo, with the latter only. The reduction of the observations has since been effected, and the results are now presented. The main base at Riobamba was divided into two sections, and the southern of these was measured twice by each method, the difference between the two results with the metal bar amounting to only 6·6 millimetres, or $\frac{1}{500000}$ of the total length. The results for the whole base obtained with the Jäderin apparatus showed a close agreement with the value adopted as the result of the measurement with the bimetallic bar, that given by the steel wire being, however, more dependable than by the brass, and it is estimated that this method may be trusted to be correct within $\frac{1}{1000000}$ or $\frac{1}{2000000}$. The northern base, which will serve only as a control, was measured with the Jäderin wires only; but for the third base, to be eventually measured on the seashore near Payta, the bar will probably be employed. The principal and secondary astronomical observations have all been made, and the results are recorded as regards the latitude of the main stations—Payta, Riobamba, Panecillo, and Tulcan; the differences in longitude had not been completely worked out. It was in the geodetic work that the principal delay had occurred, and out of thirty stations six or seven remained to be occupied. A number of

observations for the latitude of stations of the third order had been made, and much magnetic and topographical work done, including a map, on the scale of 1 : 500,000, of the Inter-Andine region. The levelling operations were to be begun during the present season, in which it is also hoped to complete the observations in the northern section, to carry forward the geodetic work in the southern section, as well as certain additional astronomical observations; leaving for succeeding years the geodetic measurements in the Cuença-Payta section, the measurement of the Payta base, the pendulum observations (which have lately been in abeyance), and, if possible, the connection of Puna island with the southern series.

The Blackwater Rivers of South America.—The subject of these rivers, which for many years have attracted special attention on the part of travellers and geographers, is exhaustively discussed in the latest issue of the *Münchener Geographische Studien* by Dr. Josef Reindl. With characteristic German thoroughness, the author begins with a sketch of the whole physical geography of the region in which such black-water rivers are met with, and which, as he shows, embraces a far larger area than was supposed by Humboldt, one of the first travellers to approach the subject in a scientific spirit, though the phenomenon had been noticed even on the occasion of Orellana's discovery of the course of the Amazon. Under the heading "Hydrography" we find a detailed description of the rivers themselves, which are especially characteristic of British Guiana, the region of the upper Orinoco and Rio Negro, the upper and lower Amazon valley, and the Brazilian mountain region of the Serra do Mar. Then follow brief accounts of certain special features, such as the occurrence of swamp formations, etc., in the domain of the black-water rivers, and the analogies presented by the rivers of other continents; while the final section of all discusses the cause of the phenomenon, and thus forms the climax of the whole study, to which alone detailed reference need be made here. After summarizing, in chronological order, the opinions which have been expressed as to the cause of the coloration from the time of Robeiro de S. Payo (1743) onwards, Dr. Reindl examines the general principles concerned in the coloration of water, showing that absolutely pure water seen from above appears absolutely black when of sufficient depth to allow of the absorption of all the rays which strike it, but that it has in itself a blue colour when the rays pass through it to the eye, as it absorbs those of all other colours contained in white light more readily than the blue. This blue colour is modified by the presence either of suspended particles or dissolved substances. Applying these principles, he shows that the great clearness of the black-water rivers would account in a measure for their dark colour when of sufficient depth, but that as they appear dark also in shallow places this cannot be the efficient reason. Such streams occur only in regions where large masses of decaying vegetable matter are present, and their water is exceptionally rich in dissolved organic matter (humic acids and their compounds). They are also only found in regions, the geological formations of which are rich in silicates (gneiss, granite, sandstone, etc.), and rivers which pass out of these formations into limestone regions at once lose their black colour. These facts permit a solution of the problem, for Dr. Reindl has found by laboratory experiments that water mixed with peat or other humus only acquired a dark colour in the presence of alkalis such as are derived from the silicates of the geological formations above alluded to. The loss of the dark colour in association with limestone is due to the chemical combinations which take place between the organic acids and the calcium or magnesia, the resulting products being not readily dissolved, and therefore falling to the bottom. This is the cause of the dark colour of the beds of the white-water streams, whereas those of the black-water streams, from a parallel chemical reason, are generally white.

The Saramacca River, Dutch Guiana.—A brief account of this expedition appears in the *Tijdschrift van het K. Nederl. Aardr. Genootschap*, Deel. xx No. 4. The leader, Herr A. J. van Stockum, and his companions left their camp at the confluence of the Saramacca and Tukumuta on March 6 last, and after three days reached a fall about 16 feet high, which necessitated a portage. Two days' journey further upstream the Tarve creek was passed, possibly a connection with the Surinam river, and then the Saramacca became shallow, and was encumbered with bushes and fallen trunks. On the 16th the obstacles became so numerous that Herr van Stockum decided to proceed no further. A hill about 1600 feet high, which he named the Zuidheuvel (South hill), in lat. 3° 47′ N. approximately, afforded a good view of the country. To the south lay hills connected with a spur of the Wilhelmina range, and at a short distance towards the north-west the southernmost summits of the Emma range (see vol. xx. p. 656), long lofty ridges sloping up from the north and ending in precipices on the south. Probably the observations, when worked out, will show that the watershed between the Surinam and Saramacca converges to the same point, so that the source of the latter river lies at the knot formed by the junction of the three ranges. On his return journey, Herr van Stockum ascended a mountain to the east of the river near Mombasu, which rose fully 2200 feet above its base, and here also he took bearings of the conspicuous points.

Trigonometrical Survey of Brazil.—We learn from *Science* (June 12, 1903) that arrangements have been made by the Brazilian Government for the commencement of a survey of the country on modern scientific lines. Reconnaissance work for the triangulation of the state of Rio Grande do Sul was to be begun this summer by a commission under Colonel F. de Abreu Lima. It is proposed to measure bases at Porto Alegre and Uruguayana, and to connect the two cities by triangulation. The resulting arc will cover about 6½° of longitude in 30° S.

AUSTRALASIA AND PACIFIC ISLANDS.

Expedition to British New Guinea.—An expedition will start very shortly to British New Guinea, equipped by and under the leadership of Major W. Cooke Daniels, who served in the United States Army during the Cuban campaign as Adjutant-General of Division, and has also travelled extensively in the tropics. He will be accompanied by Dr. C. G. Seligmann, late of the clinical laboratory of St. Thomas's Hospital, and a member of the Cambridge Anthropological expedition to Torres strait, New Guinea, and Sarawak, organized by Dr. A. C. Haddon; Dr. W. Mersh Strong, of Trinity College, Cambridge, and Mr. A. H. Dunning. Major Daniels will devote himself mainly to ethnology. Dr. Seligmann is the representative on the expedition of the Cancer Commission, and, with Dr. Strong, will investigate pathological questions of a more general character, as well as help in the ethnological inquiries. Dr. Strong is in charge of the geographical and geological observations, which it is part of the purpose of the expedition to make. The photographic work, including the taking of kinematographs, will be carried out by Mr. Dunning. A schooner yacht, with auxiliary steam-power and carrying a sea-going launch, is being sent out. The scientific equipment has been well considered, and is thoroughly adequate; the various members of the expedition have specially prepared themselves for their several duties. Assistance has been granted by the Royal Society, and a small grant given by the Government Grant Committee, while our own Society has materially helped by the loan of instruments.

POLAR REGIONS.

Ice in the Arctic Seas, 1902.—The annual report for 1902 on the ice-conditions in the arctic seas has been issued by the Danish Meteorological Institute, and, as in former years, is a most useful record, gathered from the observations of various navigators, of the state of those seas during last year. Information has come to hand in somewhat fuller measure than in the previous year, but when the usefulness of the work carried out by the institute is more widely recognized, no doubt the data will be sent in in still greater abundance. After a review of the state of the ice in the different seas around the polar area, the following general conclusions are arrived at. In 1902 the winter ice broke up very late, and the polar ice lay considerably nearer the northern coasts of Asia and Europe than in a normal year. The East Greenland current carried an abnormal quantity of pack-ice, though on the other hand an unusually small number of icebergs were carried from Greenland to the temperate seas, while the extent of polar ice in the northern branches of Baffin bay was smaller than in other recent years. The summer was rough and unsettled in all arctic and subarctic regions (with the partial exception of West Greenland), northerly and easterly winds predominating in the seas north of the Atlantic. These facts quite bear out the conclusions drawn from a consideration of the state of the ice in 1901, viz. that the accumulation of ice north of Spitsbergen caused by the prevailing westerly winds of that year would have an unfavourable influence on the state of the ice round Iceland and Greenland in 1902. Alike in the Barents sea, the region of Franz Josef Land, and around Spitsbergen, East Greenland, and Iceland the conditions were very unfavourable. The north-east, east, and south-east coasts of Spitsbergen were quite inaccessible through the summer; the pack-ice lay in a close broad belt off the coast of East Greenland, rendering access to the northern parts of the coast exceedingly difficult; while round Iceland the state of the ice was more unfavourable than ever since 1892.

MATHEMATICAL AND PHYSICAL GEOGRAPHY.

The Origin of the Mineral Oils.—The results of analyses show that the waters associated with mineral oils almost invariably contain large quantities of sodium chloride; from which the conclusion is drawn that the oil is formed from the remains of marine organisms. According to Ochsenius, an enormous quantity of organisms are destroyed suddenly by the formation and outflow of brine; according to Andrusson, the destruction of life takes place gradually, as, for example, in the Karabugas bay in the Caspian sea. Both hypotheses involve the simultaneous formation of a saline deposit. The Austrian expert, Prof. H. Höfer, who brought forward a number of questions connected with this subject at the first International Petroleum Congress at Paris in August, 1900, which will come up for discussion at the congress at Bukharest this year, has recently pointed out (*Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften in Wien. Mathematisch-Naturwissensch. Klasse*, Bd. cxi. Abt. 1) that such a formation is contrary to observed facts. The salt deposits which do occur in the neighbourhood of oil springs belong to another horizon, and are not structurally related to them. According to Höfer, who has dealt with a large amount of material, the oil-bearing deposits are shallow-water marine deposits, perhaps often formed in bags or inlets. They occur in sandstone consolidated from sand, or in conglomerate from pebbles, and these indicate a sudden inundation from adjacent land; the marine fauna at the place of deposition was destroyed by the sudden influx of fresh water. The phenomenon can be observed on a large scale at the present day on the south and east coasts of Florida, when

the occasional outbursts of fresh water from the marshes of the everglades kill the fishes in the surrounding sea in immense numbers.

GENERAL.

Hugi and the Science of Glaciers.—In the twelfth number of the *Münchener Geographische Studien*, Dr. Krehbiel gives a full account of the explorations and researches among the peaks and glaciers of the Bernese Oberland carried out in the first half of the nineteenth century by Franz J. Hugi (1796–1855), a native of Canton Solothurn, and a professor of natural history in its chief town. The writer prefaces his work with a brief summary of the growth of glacial science. He then gives a fairly full account of Hugi's various expeditions above the snow-level, and in conclusion carefully investigates and estimates the importance of his scientific work and the extent to which he advanced the knowledge of the nature of glaciers. Hugi was distinguished, it is pointed out, as the first scientific explorer who was also a mountaineer; as the inventor of winter mountaineering; and the establisher of the fact that the glaciers' advance is not stopped at that season. He made careful and accurate measurements of the motion of the glaciers, and threw some light on the process by which firn or névé is transmuted into ice; he defined "the snow-level," recognized the nature of the glacier granules, and studied the motion of the ice and the origin of its crevasses, laying foundations which his successors have found to a large extent serviceable. Dr. Krehbiel suggests that Hugi's share in the scientific exploration of his native mountains has been recently somewhat overlooked. Full justice was done to it in this country, at any rate, by James Forbes. References to Hugi will be found on twenty-two pages of his 'Travels through the Alps.' Two facsimiles of Hugi's map accompany the treatise.

Seventy-fifth Anniversary of the Founding of the Berlin Geographical Society.—The celebration of the founding of the Berlin Geographical Society, which it is the custom to hold every five years for the purpose of reviewing periodically the condition and progress of the Society, took place this year with exceptional *éclat*, on the occasion of the completion of the seventy-fifth year of the Society's existence. It so happened that the anniversary practically coincided with the seventieth birthday of the veteran German geographer, Baron von Richthofen, and the opportunity was taken to combine the two celebrations. At the meeting held on May 4, the president, Prof. Hellmann, delivered an address, in which, before dealing with the five-yearly period just completed, he passed in review the history of the Society from its foundation in 1828, dividing it into three characteristic epochs. In its early days, in which it enjoyed the support of such masters of the science of geography as Humboldt and Ritter, the Society was concerned rather with the diffusion of a knowledge of geographical work done elsewhere, and a discussion of the results obtained, than with independent exploration; but from about 1859 onwards a period of great exploring activity on the part of its members set in, which especially characterized the work of the Society during the second period. The third period, although continuing the work of its predecessor in this direction to some extent (as, *e.g.*, in the Antarctic), has been characterized by more "intensive" geographical research, in the form of the detailed examination of smaller areas, or the investigation of special problems. It has also been marked by a continuous improvement in the value of the Society's publications, culminating in the inauguration of the present excellent *Zeitschrift*. It has also seen the commencement of that model of bibliographical enterprise, the *Bibliotheca Geographica*, of which the eighth volume was lately issued. This literary activity has been particularly well marked during the last five years, of which a more detailed review was given by

Prof. Hellmann. They have seen the inauguration (in 1901) of the technical meetings of the Society (corresponding to our own afternoon meetings), in which special scientific questions have been discussed. As regards the papers read at the general meetings, a variation in the distribution of the subjects among the continents has been noticeable of late, Africa having yielded the first place in this respect to Asia. The opening of the new premises of the Society in 1899, and the Berlin meeting of the International Geographical Congress in the same year, also fall within the last period of five years. The Society is to be warmly congratulated on its ability to show a record of such excellence, and our best wishes are given to it for the continuance of its career of usefulness. A new departure, which will still further contribute to this in the future, was inaugurated at the meeting by the foundation of the "Ferdinand von Richthofen Stiftung," in honour of the distinguished geographer. A capital sum of 26,000 marks, which had been collected by a committee appointed for the purpose, was handed over to Baron von Richthofen as a fund for the encouragement of geographical progress, the yearly proceeds to be devoted to the support of journeys of geographical research, grants to geographical students, and such other purposes as may eventually be determined.

Geology and Geography.—A section of Prof. Lapworth's anniversary address to the Geological Society on February 20 last was devoted to the somewhat difficult question of the relations between the sciences of geology and geography. The key-note of his remarks was the mutual dependence between the two which has always been, and must continue to exist, cordial recognition being given to the services rendered by geography to geology, no less than *vice versâ*. The two sciences were spoken of as sharing between them the collective study of the Earth, the surface of the globe being regarded as their common limit and common property. As a representative of the physical sciences as contrasted with those related to man, it was only natural that Prof. Lapworth should limit his views to the physical side of geography, which, of course, is the one as to which the difficulty of drawing a dividing-line alone arises. But by leaving out of view the relations of geography to the science of man on the opposite side, he necessarily failed to give prominence to the central distinction between geography as a whole and the sister science, which depends rather on the standpoint of the student and the motive with which his inquiries are made, than on any hard-and-fast dividing-line between portions of a science which is essentially one in regard to the facts which form its basis, though for convenience-sake it may be subdivided. Such limits of time or space as those between the present and the past, or between what lies above or below the existing surface, must be more or less arbitrary and artificial, however convenient for practical purposes; and it is only when he looks beyond the mere surface features of the globe to the effects which these have on the human and other life upon it, that the geographer fully substantiates his claim to be the exponent of an independent science. None the less, our thanks are due to Prof. Lapworth for his generous appreciation of the value of geography, in spite of the tendency which it may occasionally manifest to trespass on ground which the geologist regards as his own.

Marine Investigation: Course of Instruction.—It is announced that, if a sufficient number of students send in their names, a course of instruction on marine investigations will be held at Bergen from September 1 to November 1, by Dr. Johan Hjort and several coadjutors. The course will consist partly of lectures and practical experiments; partly of laboratory work, demonstrations, and excursions. The instruction will be free of charge, but microscopes, etc., must be brought by students. Applications should be made to Dr. Hjort at Bergen before August 15. A similar course was held by the promoters last winter.

OBITUARY.

George Robert Boyle.

We regret to record the death, at the age of sixty, of George Robert Boyle, a Fellow of the Society. Mr. Boyle had been connected for forty-six years with the British and Foreign Blind Association. Mr. Boyle took the greatest interest in his work, and became the inventor of many improvements in connection with the making of Braille books and implements for the blind, and also of the cheapest and best embossed maps for the blind and seeing, several of which are at the Society, and many more in use at the large schools. In 1897 the British and Foreign Blind Association brought out in interpointed Braille 'the story of Nansen as told by himself.' It was an admirable stereotyped and easily read volume, with close lines on each page, a great improvement on the original French Braille system, and even on the perfectioned system as introduced by Dr. Armitage, the founder of the institution. Mr. Boyle deserved the greatest credit for the complete success which had at last crowned his work.

GEOGRAPHICAL LITERATURE OF THE MONTH.

Additions to the Library.

By EDWARD HEAWOOD, M.A., *Librarian*, R.G.S.

The following abbreviations of nouns and the adjectives derived from them are employed to indicate the source of articles from other publications. Geographical names are in each case written in full:—

A. = Academy, Academie, Akademie.
Abh. = Abhandlungen.
Ann. = Annals, Annales, Annalen.
B. = Bulletin, Bollettino, Boletim.
Com. = Commerce.
C. Rd. = Comptes Rendus.
Erdk. = Erdkunde.
G. = Geography, Geographie, Geografia.
Ges. = Gesellschaft.
I. = Institute, Institution.
Iz. = Izvestiya.
J. = Journal.
k. u. k. = kaiserlich und königlich.
M. = Mitteilungen.
Mag. = Magazine.
Mem. = Memoirs, Mémoires.
Met. = Meteorological.
P. = Proceedings.
R. = Royal.
Rev. = Review, Revue.
S. = Society, Société, Selskab.
Sitzb. = Sitzungsbericht.
T. = Transactions.
V. = Verein.
Verh. = Verhandlungen.
W. = Wissenschaft, and compounds.
Z. = Zeitschrift.
Zap. = Zapiski.

On account of the ambiguity of the words *octavo*, *quarto*, etc., the size of books in the list below is denoted by the length and breadth of the cover in inches to the nearest half-inch. The size of the *Journal* is 10 × 6½.

A selection of the works in this list will be noticed elsewhere in the "Journal."

EUROPE.

Alps. *Alpine J.* **21** (1903): 417–420. **Brigg.**

The Peaks, Passes, and Glaciers between the Col de la Galise, and the Aiguille de la Sassière and the Bassac Nord (Central Graians). By W. A. Brigg. *With Map.*

Alps. **Penck and Brückner.**

Die Alpen im Eiszeitalter. Von Dr. A. Penck und Dr. E. Brückner. Lieferung 5. Leipzig: C. H. Tauchnitz, 1903. Size 10½ × 7½, pp. 433–544. *Map and Illustrations. Presented by the Publisher.*

Alps—Chamonix. **Whymper.**

Chamonix and the Range of Mont Blanc. A Guide by Edward Whymper. Eighth Edition. London: John Murray, 1903. Size 7½ × 5, pp. xiv. and 206. *Price* 3*s. net. Maps and Illustrations. Two copies. Presented by the Author and Publishers.*

Alps—Mont Blanc. *Ann. Club Alpin Français* **28** (1901): 425-435 **Forel.**

Les Glaciers du Mont-Blanc en 1780. Par M. F.-A. Forel. *With Plate.*

Austria—Historical. **Pichler.**

Austria Romana. Geographisches Lexikon aller zu Römerzeiten in Östreich genannten Berge, Flüsse, Häfen, Inseln, Länder, Meere, Postorte, Seeen, Städte, Strassen, Völker. I. Von Fritz Pichler. (Quellen und Forschungen zur alten Geschichte und Geographie, herausgegeben von W. Sieglin. Heft 2.) Leipzig: E. Avenarius, 1902. Size 9½ × 6½, pp. 102. *Map.*

Azores. *B.S.R. Belge G.* **27** (1903): 129-157. **Verschuur.**

Les îles Açores. *With Map.*

Translated from the Dutch of G. Verschuur (*Tijdschrift*, Netherlands Geographical Society).

Balkan Peninsula. **Curtis.**

The Turk and his Lost Provinces. Greece, Bulgaria, Servia, Bosnia. By William Eleroy Curtis. Chicago, etc.: Fleming H. Revell Co., 1903. Size 9 × 6, pp. 396. *Illustrations. Price* 7*s.* 6*d.*

On account of the Balkan countries and Greece for the general reader, by an American journalist.

Baltic. *Petermanns M.* **49** (1903): 25-28, 77-83. **Geinitz.**

Die geographischen Veränderungen des südwestlichen Ostseegebiets seit der quartären Abschmelzperiode. Von Prof. Dr. E. Geinitz. *With Map.*

Belgium—Coal. *La G., B.S.G. Paris* **7** (1903): 284-288. **Ertborn.**

Le bassin houiller de la campine. Par Baron O. van Ertborn.

Bulgaria. *Deutsch. Rundschau G.* **25** (1903): 369-370. ——

Die Weingartenfläche Bulgariens.

Central Europe. **Partsch.**

Central Europe. By Joseph Partsch. London: W. Heinemann, 1903. Size 9½ × 6, pp. xiv. and 358. *Maps and Diagrams. Price* 7*s.* 6*d. Presented by the Publisher.* [To be reviewed.]

Denmark—Language. **Harvey.**

Danish Self-taught, with Phonetic Pronunciation (Thimm's System), containing Vocabularies, Idiomatic Phrases, and Dialogues; Elementary Grammar; Commercial, Trading, and Legal Terms; Travel Talk; Shooting, Fishing, Photography, Cycling, etc., etc. Edited by W. F. Harvey. London: E. Marlborough & Co., 1903. Size 7 × 4½, pp. 120. *Price* 2*s.* 6*d. Presented by the Publishers.*

Denmark—Meteorology. ——

Nautical-Meteorological Annual 1902, published by the Danish Meteorological Institute. Kjøbenhavn: G. E. C. Gad, 1903. Size 12½ × 9½, pp. xxxii. and 182. *Charts. Presented by the Danish Meteorological Institute.*

Includes the annual report for 1902 on ice in the Arctic seas (*ante*, p. 218).

France—Ain Valley. **Delebecque.**

Contribution à l'étude des terrains glaciaires des vallées de l'Ain et de ses principaux affluents. Par A. Delebecque. Paris: C. Béranger, 1902. Size 10 × 6½, pp. 14. *Map. Presented by the Author.*

France—Alps. *B.S.G. Com. Paris* **25** (1903): 28-38. **Bougault.**

Richesses hydrauliques des Alpes françaises, leur situation actuelle, leur avenir. Par Paul Bougault.

Norway. ——

Norge i det Nittende Aarhundrede. Tekst og Billeder af Norske Forfattere og Kunstnere. 2 Volumes. Kristiania: A. Cammermeyer, 1900. Size 13 × 10½, pp. (vol. i. 436); (vol. ii. 468). *Maps. Plates and Illustrations. Presented by Dr. Fridtjof Nansen.*

A superbly illustrated work on every branch of knowledge regarding Norway, including articles by leading authorities on trade, industries, fisheries, statistics, literature, art, etc., as well as on the physical aspects of the country.

Sweden—Geology. **Blomberg and Holm.**

Geologisk Beskrifning öfver Nerika och Karskoga Bergslag samt Fellingsbro Härad. Af Albert Blomberg och G. Holm. (Sveriges Geolog. Undersökning. Stockholm, 1902. Ser. Ca., No. 2.) Size 12½ × 10, pp. 124. *Maps and Plates.*

Sweden—Geology. **Blomberg and Lundbohm.**

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Pugh's Queensland Almanac and Directory for 1903. Brisbane: Gordon & Gotch. Size 9 × 5½, pp. xl. and 932. *Presented by the Under-Secretary for Queensland.*

Queensland. ——

Queensland. Blue Book for the year 1902. Brisbane, 1903. Size 13½ × 8½, pp. xxxvi. and 244.

Queensland. *Queensland Mining J.* **4** (1903): 105–118.

The Queensland Mining Industry. Review of the year 1902. Report by the Under Secretary for Mines. *With Plans.*

PHYSICAL AND BIOLOGICAL GEOGRAPHY.

Drift-ice. *Ann. Hydrographie* **31** (1903): 204–206. **Schott.**

Die diesjährige grosse Eistrift an der Ostkante der Neufundlandbank. Von Dr. G. Schott. *With Diagram.*

Geomorphology. *Quarterly J. Geolog. S.* **59** (1903): 180–188. **Sollas.**

The Figure of the Earth. By W. J. Sollas. *With Diagrams.*

See note in *Journal* for March, 1903 (p. 326).

Glacial Epoch. *Tijds. K. Ned. Aard. Genoots. Amsterdam* **20** (1903): 386–401. **Lorié.**

De voorgestelde eenheid van het Ijstijdvak. Door Dr. J. Lorié.

Ground-ice. *Verh. Russ.-K. Mineralog. Ges. St. Petersburg* **40** (1902): 203–209. **Bunge.**

Einige Worte zur Bodeneisfrage. Von Dr. A. v. Bunge.

Meteorology. *Meteorolog. Z.* **20** (1903): 218–220. **Hegyfoky.**

Die tägliche Periode der Gewitter im Flach- und in Bergland. Von J. Hegyfoky.

Meteorology. *Meteorolog. Z.* **20** (1903): 193–214. **Margules.**

Ueber Temperaturschwankungen auf hohen Bergen. Von Max Margules.

Meteorology—Dustfalls. *Deutsch. Rundschau G.* **25** (1903): 368–369. ——

Neue Staubfälle aus der Sahara.

Meteorology—Winds. *Monthly Weather Rev.* **31** (1903): 18. **Elmer.**

High winds in mountain valleys. By A. D. Elmer.

Meteorology—Winds. *B.S.G. l'Est* **24** (1903): 5–11. **Millot.**

Les rafales de montagnes. Par C. Millot.

Oceanography. *Ann. G.* **12** (1903): 1–12, 97–108. **Caullery.**

Le Plankton, vie et circulation océaniques. Par M. Caullery.

Oceanography—International Research. *G. Tidskrift* **17** (1903–1904): 49–56. **Ostenfeld.**

De internationale Havundersøgelser. Af C. H. Ostenfeld.

Physical Geography. **Supan.**

Grundzüge der physischen Erdkunde. Von Prof. Dr. A. Supan. Dritte . . . Auflage. Leipzig: Veit & Co., 1903. Size 9½ × 6, pp. x. and 852. *Maps and Illustrations. Presented by the Author.*

Physical Geography—Bibliography. ——

International Catalogue of Scientific Literature. First Annual Issue. J. Geography, Mathematical and Physical. London: Harrison & Sons, 1903. Size 8½ × 5½, pp. 268. *Price* 15*s.*

Phyto-geography. *Naturwissens. Wochenschrift*, N.F. **2** (1903): 325–328. **Graebner.**

Die Vegetationsbedingungen jüngerer und älterer Gehölzpflanzen in der Heide. Von P. Graebner.

Petroleum. **Coste.**

Canadian Mining Institute. The Volcanic Origin of Natural Gas and Petroleum. By E. Coste. Ottawa, 1903. Size 9 × 6, pp. 50. *Presented by the Author.*

Rivers. *Geolog. Mag.* **10** (1903): 145–148. **Davis.**

The Development of River Meanders. By Prof. W. M. Davis.

Rivers—Sudd. ——

The Nile Sudd. (From the *Illustrated Scientific News*, February, 1903, pp. 67–68.) Size 14½ × 10½. *Illustrations.*

Includes, besides four of the illustrations of the Nile Sudd given in the *Journal* for September, 1902, others showing the growth of water-hyacinth on the rivers of Florida.

Sedimentation. *Sci. T.R. Dublin S.* **7** (Ser. ii.) (1902): 391–402. **Joly.**
Some Sedimentation Experiments and Theories. By J. Joly.

Seismology. *A. Travers le Monde, Tour du M.* **9** (1903): 109–111. ——
Vue d'ensemble des Phenomènes volcaniques de 1902. *Map.*

The map shows the probable lines of propagation of the volcanic movements.

Solar Radiation. *P.R.S. Edinburgh* **23** (1899–1901): 296–311. **Knott.**
Solar Radiation and Earth Temperatures. By Prof. C. G. Knott. *With Diagram.*

Terrestrial Magnetism. **Schütz.**
Die Lehre von dem Wesen und den Wanderungen der magnetischen Pole der Erde. Ein Beitrag zur Geschichte der Geophysik. Von Dr. Ernst Harald Schütz. Berlin: D. Reimer (Ernst Vohsen), 1902. Size 10 × 6½, pp. xii. and 76. *Maps and Facsimile.*

Terrestrial Magnetism. *Ann. Club Alpin. Française* **28** (1901): 441–450. **Mathias.**
L'Alpinisme et les études de Magnétisme Terrestre. Par M. E. Mathias.

Terrestrial Physics. *Riv. G. Italiana* **10** (1903): 143–146. **Pagnini.**
L'ipotesi del P. Timoteo Bertelli sulla distribuzione della densità nell' interno della terra. P. Pagnini.

Terrestrial Physics. *Meteorolog. Z.* **20** (1903): 49–53. **Woeikof.**
Problème des Wärmehaushaltes des Erdballs. Von A. Woeikof.

Underground Temperature. *T.R.S. Edinburgh* **40** (1900–1901): 157–186. **Heath.**
Observations of the Edinburgh Rock Thermometers. By T. Heath. *With Diagrams.*

Valleys. *Petermanns M.* **49** (1903): 73–77. **Hess.**
Der Taltrog. Von Prof. Dr. H. Hess. *With Maps and Profiles.*

Volcanoes. **Stübel.**
Ueber die Genetische Verschiedenheit Vulkanischer Berge. Eine Studie zur Wissenschaftlichen Beurtheilung der Ausbrüche auf den Kleinen Antillen im Jahre 1902. Von Alphons Stübel. (Veröffentlichung der Vulkanologischen Abtheilung des Grassi-Museums zu Leipzig.) Leipzig: Max Web, 1903. Size 14 × 11, pp. viii. and 86. *Illustrations. Price* 12*s.*

ANTHROPOGEOGRAPHY AND HISTORICAL GEOGRAPHY.

Anthropology. **Kaindl.**
Die Volkskunde. Ihre Bedeutung, ihre Ziele und ihre Methode. Mit Besonderer Berücksichtigung ihres Verhältnisses zu den Historischen Wissenschaften. Ein Leitfaden zur Einführung in die Volksforschung von Dr. Raimund Friedrich Kaindl. (Die Erdkunde, xvii. Teil.) Leipzig u. Wien: F. Deuticke, 1903. Size 10 × 7, pp. xi. and 150. *Illustrations. Price* 5*s.*

One of a series of treatises on the several branches of geography.

Early Travel. **Dorez.**
Itinéraire de Jérome Mauraud d'Antibes à Constantinople (1544). Texte Italien publié pour la première fois avec une Introduction et une Traduction par Leon Dorez. (Recueil de Voyages et de Documents pour servir à l'histoire de la Géographie depuis le xiii^e^ siècle jusqu'a la fin du xvi^e^ siècle, vol. xvii.) Paris: E. Leroux, 1901. Size 11 × 7½, pp. lviii. and 378. *Plates. Price* 30 *fr.*

Historical—British Navy. **Clowes and Others.**
The Royal Navy. A History from the Earliest Times to the Present. By William Laird Clowes. Assisted by Sir Clements Markham, Captain A. T. Mahan, Mr. H. W. Wilson, Colonel Theodore Roosevelt, etc. In 7 vols. Vols. 5, 6, and 7. London: S. Low, Marston & Co., 1900–1903. Size 10½ × 7½, pp. (vol. 5, xx. and 624); (vol. 6, xvi. and 592); (vol. 7, xvi. and 628). *Maps, Plates, and Illustrations, etc. Price* 25*s. net per vol.*

The seventh volume completes the work, which includes valuable discussions by Sir C. Markham on the geographical work done by officers of the Royal Navy.

Historical—Columbus. **Thacher.**
Christopher Columbus. His Life, His Work, His Remains, as revealed by original printed and manuscript records, together with an Essay on Peter Martyr of

Anghera and Bartolomé de las Casas, the First Historians of America. By John Boyd Thacher. Volume i. New York: G. P. Putnam's Sons, 1903. Size 11½ × 8, pp. x. and 670. *Maps, Portraits, and Facsimiles. Price* 36*s. net.*

This sumptuous work will be reviewed when the three volumes are complete.

Historical—Marco Polo. **Yule and Cordier.**

The Book of Ser Marco Polo the Venetian concerning the Kingdoms and Marvels of the East. Translated and edited, with Notes, by Colonel Sir Henry Yule. Third Edition, revised throughout in the light of recent discoveries by Henri Cordier (of Paris). With a Memoir of Henry Yule by his daughter, Amy Frances Yule. In two volumes. London: J. Murray, 1903. Size 9½ × 6, pp. (vol. i.) cii., 144, and 462, (vol. ii.) xxii. and 662. *Maps and Illustrations. Price* £3 3*s. net. Presented by the Publisher.*

BIOGRAPHY.

Grant. **Smith.**

Physician and Friend. Alexander Grant, F.R.C.S. His Autobiography and his Letters from the Marquis of Dalhousie. Edited by George Smith. London: John Murray, 1902. Size 9 × 5½, pp. 218. *Portrait. Price* 10*s.* 6*d. net. Presented by the Author.*

Hugi. **Krehbiel.**

Franz Joseph Hugi in seiner Bedeutung für die Erforschung der Gletscher. Von Albert Krehbiel. (Münchener geographische Studien herausgegeben von S. Günther, Zwölftes Stück.) München: T. Ackermann, 1902. Size 9½ × 6, pp. 92. *Maps.*

See note in Monthly Record (*ante*, p. 219).

Radde. *Alpine J.* **21** (1903): 414–416. **Déchy.**

Dr. Gustav Radde. By M. de Déchy.

Richthofen. *Naturw. Wochenschrift* **2** (1903): 361–370. **Lampe.**

Ferdinand Freiherr von Richthofen. Von Dr. F. Lampe.

Wild. *Deutsch. Rundschau G.* **25** (1903): 375–376. ——

Heinrich v. Wild. *With Portrait.*

GENERAL.

Bibliography. **Baschin.**

Bibliotheca Geographica herausgegeben von der Gesellschaft für Erdkunde zu Berlin, bearbeitet von Otto Baschin. Band viii. Jahrgang 1899. Berlin: W. H. Kühl, 1902. Size 9½ × 6, pp. xvi. and 512.

British Empire. **Wall.**

The British Empire Year Book, 1903. An Annual Statistical Volume of Reference, compiled with the assistance of H.M. Imperial and Colonial Governments, by Edgar G. Wall. First Year of Publication. London, etc.: E. Stanford. Size 10 × 6, pp. viii. and 1280. *Map. Price* 21*s. net. Presented by the Publishers.*

Encyclopædia. **Meyer.**

Meyers Grosses Konversations-Lexikon. Ein Nachschlagewerk des allgemeinen Wissens. Sechste, gänzliche neubearbeitete, und vermehrte Auflage. Dritter Band. Bismarck-Archipel bis Chemnitz. Leipzig u. Wien: Bibliographisches Institut, 1903. Size 10 × 6½, pp. 924. *Maps, Plates, and Illustrations. Price* 10*s.*

Exploration. **Berdrow.**

Prochaskas Illustrierte Jahrbücher. Illustriertes Jahrbuch der Weltreisen und geographischen Forschungen. Von Wilh. Berdrow. II. Jahrgang 1903. Leipzig u. Wien: K. Prochaska. Size 11½ × 8, columns 286. *Price* 1*s.* 6*d. Illustrations.*

Geographical names. **Nagl.**

Geographische Namenkunde. Methodische Anwendung der Namenkundlichen Grundsätze auf das Allgemeiner Zugängliche Topographische Namenmaterial. Von J. W. Nagl. (Die Erdkunde, xviii. Teil.) Leipzig u. Wien: F. Deuticke, 1903. Size 10 × 7, pp. vii. and 136. *Illustrations. Price* 5*s.*

One of a useful series of monographs dealing with the aims and methods of the various branches of geographical science.

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EUROPE.

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Isle of Man, Economic Geology of the, with special reference to the Metalliferous Mines. (Reprinted from the Memoir on the Geology of the Isle of Man, 1903.) 1*s.* 6*d.*

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ASIA.

Aral Sea. **Petermanns Geographische Mitteilungen.**

Tiefenkarte des Aral-Sees. Nach dem russischen Original reduziert. Scale,

1 : 2,000,000 or 31·5 stat. miles to an inch. *Petermanns Geographische Mitteilungen*, Jahrgang 1903, Tafel 12. Gotha : Justus Perthes. *Presented by the Publisher.*

Central Asia. **Borghese.**

Carta del Tien Scian Centrale con l'itinerario della spedizione del Principe Scipione Borghese (Guigno-Settembre, 1900) Secondo le Note e i Rilievi del Prof. G. Brocherel. Scale 1 : 600,000 or 9·4 stat. miles to an inch. *Presented by Prince Scipione Borghese.*

This map shows the route of the expedition of Prince S. Borghese in the Tian Shan region immediately to the east and south-east of Issik Kul, from June to September, 1900. It is based upon the notes and surveys of Prof. G. Brocherel, who accompanied the prince, and adds considerably to our knowledge of this hitherto very imperfectly explored mountainous district. In addition to the mapping, Prof. Brocherel took an important series of photographs of the region, some of which are now in the Society's collection.

AFRICA.

Morocco. **De Segonzac and de Flotte Roquevaire.**

Itinéraires au Maroc du Marquis de Segonzac. Dressés avec la collaboration de R. de Flotte Roquevaire. Scale 1 : 250,000 or 3·9 stat. miles to an inch. 11 sheets. Paris : Henry Barrère, 1903. *Price 15 fr.*

The routes followed by the Marquis de Segonzac's expedition in Morocco extend from Tangier and Melilla on the Mediterranean coast as far south as Ari Aiach in about lat. 30° 30′ N., and from Mogador and Tiznit on the west coast to Marrakesh. These routes are laid down upon eight sheets, in colours, on the 1 : 250,000 scale, in addition to which a considerable amount of detailed information concerning the country traversed is given. The route surveys have been plotted and adjusted with the assistance of Mons. R. de Flotte Roquevaire, the well-known authority on the cartography of Morocco, whose general map of this country is, perhaps, in many respects the best in existence at the present time. In addition to the eight sheets showing the route, there are three others of sections, and inset plans of Tarudant and Tiznit on the scale of 1 : 20,000. It is to be regretted that there is no information on the map concerning the character of the surveys upon which it is based, or how the positions of places have been fixed.

AMERICA.

Argentine Republic. **Smith.**

An Economic Map of the Argentine Republic. Compiled by J. Russell Smith for the *Bulletin of the American Geographical Society*, No. 2, 1903. Scale 1 ; 8,800,000 or 138·8 stat. miles to an inch. *Presented by J. Russell Smith, Esq.*

The small scale of this map, and its style of production, hardly do justice to the most useful information it contains. From an inspection of the table of reference in a corner of the map, it will be seen that an attempt has been made to show, amongst other things, forest land, limits of vine and sugar cultivation, meat freezing and extract establishments, rainfall, limits of wheat-growing territory, political boundaries, railways, and much besides that is very interesting and important from the point of view of commercial geography ; but as a map it is somewhat of a failure, owing to the fact that it has been attempted to show all this information in symbols in black instead of by different colours, and that the scale adopted is much too small for the purpose.

Canada. **Surveyor-General of Canada.**

Sectional Map of Canada. Scale 1 : 190,080 or 3 stat. miles to an inch. Thunder Hill Sheet (29), West of Principal Meridian. Revised to April 21, 1903. Prince Albert Sheet (46), West of Second Meridian. Revised to November 24, 1902. Rush Lake Sheet (51), West of Third Meridian. Revised to April 28, 1903. Brazeau Sheet (86), West of Fifth Meridian. Revised to April 16, 1903. Rainy Hills Sheet (67), West of Fourth Meridian. Revised to March 30, 1903. Surveyor-General's Office, Ottawa, 1903. *Presented by the Surveyor-General of Canada.*

Peru. **Baluarte.**

Map of Peru. Published under the authority of Don Eugenio Larrabure y Unánue, Minister of Foreign Affairs, Lima, 1903. Scale 1 : 3,000,000 or 47·3 stat. miles to an inch. R. E. Baluarte. London : G. Philip & Son. *Presented by Edward Higginson, Esq., Consul of Peru, Southampton.*

An introductory note states that this sheet has been specially produced to make known, in a succinct manner, the inducements which Peru offers for capital, immigration, and colonization. The map shows railways, roads, telegraphs, limit

of navigability of rivers, rapids, forests, etc. Upon the back of the sheet is printed useful general information concerning the country and its products.

United States. **Rand, McNally & Co.**

Indexed County and Township Pocket Maps. North Carolina. Scale 1 : 887,040 or 14 stat. miles to an inch. North Dakota. Scale 1 : 1,330,560 or 21 stat. miles to an inch. Ohio. Scale 1 : 823,680 or 13 stat. miles to an inch. Chicago and New York: Rand, McNally & Co., 1903. *Price* $0.25 *each. Presented by the Publishers.*

These are new editions.

POLAR REGIONS.

Greenland. **Engell.**

Karte von Jakobshavns-Eisfjord und die Gletscher-veränderungen. Teilweise nach Rink und Hammer entworfen. Von M. C. Engell. Scale 1 : 200,000 or 3·1 stat. miles to an inch. *Petermanns Geographische Mitteilungen*, Jahrang 1903, Tafel 11. Gotha: Justus Perthes. *Presented by the Publisher.*

GENERAL.

World. **Mackenzie.**

Physical Relief Map of the World on Mercator's Projection, embracing the Physical and Political Features. Reproduced from actual models by an entirely new process by E. A. Mackenzie. Two sheets. London: Effingham Wilson. *Price, in sheets,* £1 1*s. Presented by the Publisher.*

This is another attempt to show mountain systems and general relief by photographic reproductions of models, and the result is far from successful, the map being in many respects quite misleading. For instance, the Ural mountains and comparatively insignificant ranges in the northern part of Asia are shown as of equal elevation and importance with the Himalayas, while the great plateau of Tibet and other leading features are not at all clearly brought out. Then, again, in Africa some of the greatest land elevations are shown in comparatively lowlying countries, such as Egypt and the valley of the Nile, whilst lofty peaks, such as Kenia and Kilimanjaro, appear most insignificant.

CHARTS.

North Atlantic Ocean and Mediterranean Sea. **Meteorological Office.**

Pilot Chart of the North Atlantic and Mediterranean for July, 1903. London: Meteorological Office. *Price* 6*d. Presented by the Meteorological Office, London.*

United States Chart. **United States Hydrographic Office.**

Pilot Chart of the North Atlantic Ocean for June, and of the North Pacific for July, 1903. U.S. Hydrographic Office, Washington, D.C. *Presented by the U.S. Hydrographic Office.*

PHOTOGRAPHS.

Arabia. **Husain.**

Twenty-four Photographs of Arabia, taken by Vice-Consul Dr. S. M. Husain. *Presented by P. Devey, Esq.*

Mr. G. P. Devey has on several occasions presented photographs to our collection, and these which have lately been received from him, as the titles show, are especially interesting. They are small Kodaks, but most of them are fairly clear.

(1) Egyptian Mahmal (holy carpet) passing through Jeddah; (2) A well on the Jeddah-Mecca road, called "Ummulgurun," near Haddah; (3) Commodore Mustaf Hilmi Bey waiting on the road while his shugduf is being readjusted on the camel; (4) Entrance to Mina, a place 6 miles from Mecca; (5) A street in Mecca; (6) People stoning the big devil at Mina; (7) The Vali stoning the second devil; (8) Grand Sharif stoning the second devil; (9) Crowd of pilgrims stoning the second devil; (10 and 11) Grand Sharif's elephant collecting his toll from the fruit and sweetmeat vendors; (12) Grand Sharif going to see the Pasha of the Syrian Mahmal; (13) Guard of honour in front of the reception tent of the Grand Sharif at Mina; (14) The Vali going to the Grand Sharif's reception; (15) H.H. the Sultan of Zanzibar and his brother-in-law going to the Grand Sharif's reception; (16) Zahir-ul-Islam, son-in-law of the late Shah of Persia, going to the Grand Sharif's reception; (17) Pasha of the Egyptian Mahmal going to the Grand Sharif's reception; (18) An evening party at Mina; (19) An Arab breakfast at Mina; (20) General view of Mina; (21) Arafat camp;

(22) Mount Arafat, on which the Kadi reads sermons on the day of Haj; (23) Pilgrim at Arafat enjoying morning coffee; (24) Two Bedouin shaikhs at Arafat.

Argentine Republic.

An album of twenty-six photographic reproductions of Buenos Aires. *Presented by J. H. Fitz-Simons, Esq.*

An album of twenty-six photographic reproductions of public buildings and place of interest in Buenos Aires. The following are the titles:—

(1) Splendid Hotel; (4 and 21) Plaza de Mayo; (5) The cathedral; (6) Editori offices of the *La Prensa*; (7) Commercial exchange; (8) Pabellon Argentino; (9) Th racecourse; (10) Grand stand on the racecourse; (11) Corn Exchange; (12) Lezam park; (13) The West Railway station; (14) Aguas Corrientes bank; (15) Plaza España (16) North docks; (17) South docks; (18) Calle Callao; (19 and 20) The ne slaughter-house; (22) Entrance to the north harbour; (23) Calle Olivarria; (2 Avenida Alvear; (25) Sarmiento college; (26) Headquarters of the police.

Lofoten Islands—Caucasus—Canadian Rockies. **Woolley**

Seventeen photographs of the Lofoten islands, Caucasus, and the Canadian Rockies, taken by H. Woolley, Esq. *Presented by H. Woolley, Esq.*

Mr. Hermann Woolley is well known as a mountaineer and photographer of mor than ordinary ability, and his excellent views of the high peaks of the Caucasus an Canadian Rocky mountains, etc., have been deservedly admired by all who have see them. They are enlarged from remarkably good plates, and measure 17½ × 14 inche Those which have now been presented to the Society are most instructive from physical geography point of view.

Lofoten Islands.—(1) South end of the Raftsund from Digermulen; (2) South en of the Raftsund with Stor Molla and Lille Molla; (3) Svartsundtind and the Raftsund from Digermulen.

Caucasus.—(1) Ailama; (2) Koshtan Tau and Ulluauz-Bashi; (3) South face o Shkara; (4) South face of Janga and Kalde glacier; (5) Fytnargyn and the Ailam glacier; (6) Freshfield's Latoga; (7) Mountains at the head of the Shikildi glacier (8) Ushba from the south; (9) Ushba from the south-east; (10) Koshtan Tau.

Canadian Rockies.—(1) Mount Forbes; (2) Hungabee from Desolation valley Mount Temple group; (3) Mount Athabasca; (4) Moraine lake, Mount Temple group

Mexico. **Eckenstein**

Album containing twenty-four photographs of Mexican mountains, taken by O. Eckenstein, Esq. *Presented by O. Eckenstein, Esq.*

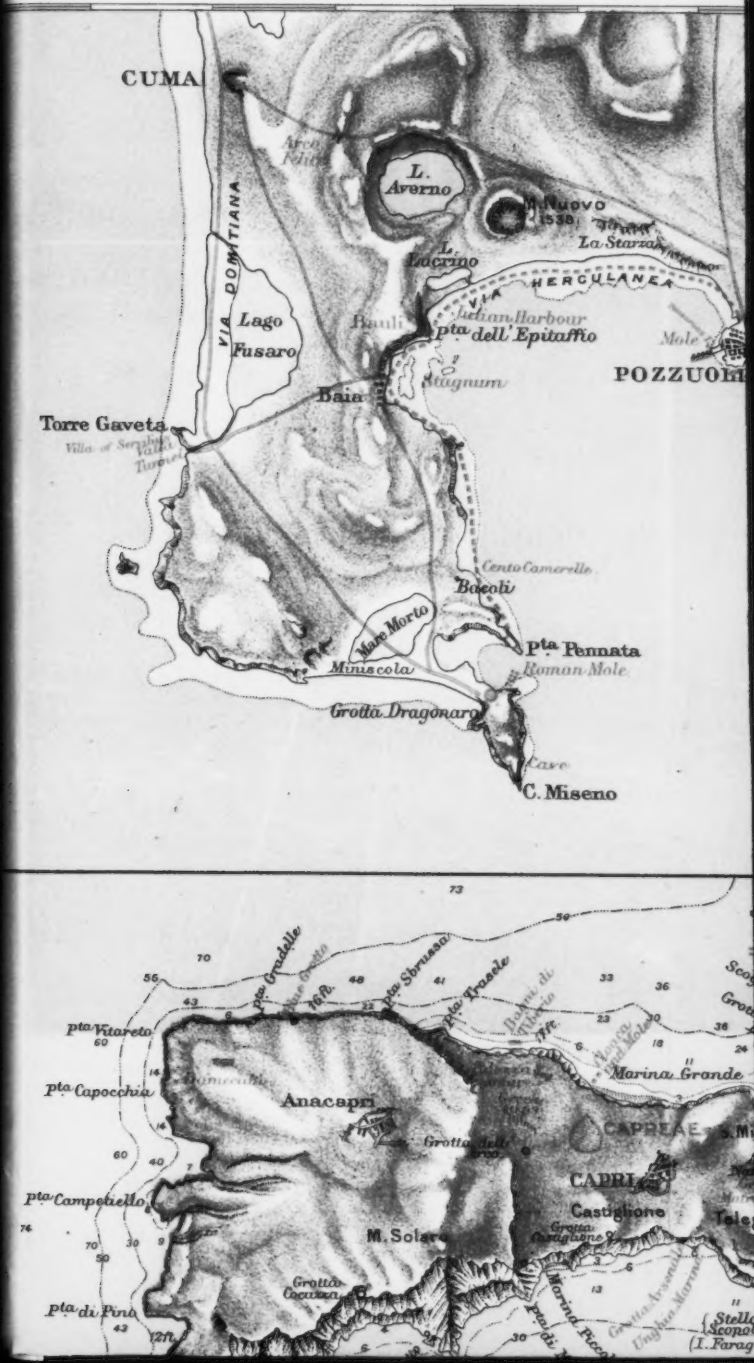
Previous to his recent travels in the Himalayas, Mr. Eckenstein visited Mexico and took this excellent little series of photographs of mountain scenery, which he has arranged in an album and presented to the Society:—

(1) Camp on west slopes of Ixtaccihuatl; (2) Ice-cave at a height of about 14,200 feet, on west slopes of Ixtaccihuatl; (3) Cabeza, the north summit of Ixtaccihuatl; (4) Pass between Cabeza and Panza; (5) Panza, the main summit of Ixtaccihuatl, height 17,343 feet; (6 and 7) Ice summit of Panza; (8) Moraine and lower end of Porfirio Diaz glacier, south side of Panza; (9) Popocatapatl, height 17,887 feet; (10) Popo catapatl, from foot of towers; (11) Nevado de Colima, lower summit; (12) Nevado de Colima; (13) Volcan de Colima, about 12,900 feet high; (14–20) Eruption of Volcan de Colima; (21) Xinanticatl, the extinct crater of Toluca; (22) Crater wall and highes summit, Xinanticatl; (23) Crater wall between Espinazo and Fraile, Xinanticatl; (24) Crater wall and second summit, Fraile, Xinanticatl.

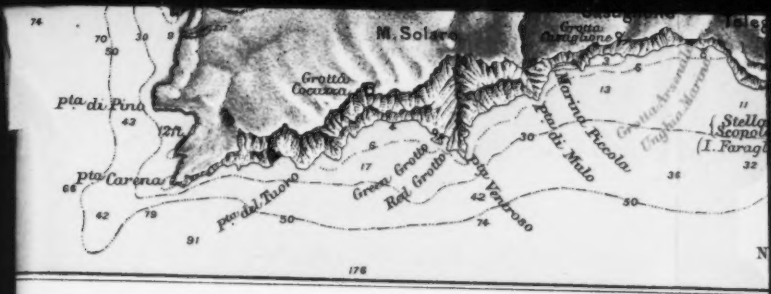
Tibetan "Curios." **Millais**

Photograph of a collection of Tibetan "curios," especially of vessels, instruments, etc., used by the lamas in their monasteries, taken by Geoffrey Millais, Esq. *Presented by Captain E. Le Mesurier.*

N.B.—It would greatly add to the value of the collection of Photo graphs which has been established in the Map Room, if all the Fellow of the Society who have taken photographs during their travels, would forward copies of them to the Map Curator, by whom they will b acknowledged. Should the donor have purchased the photographs, i will be useful for reference if the name of the photographer and hi address are given.

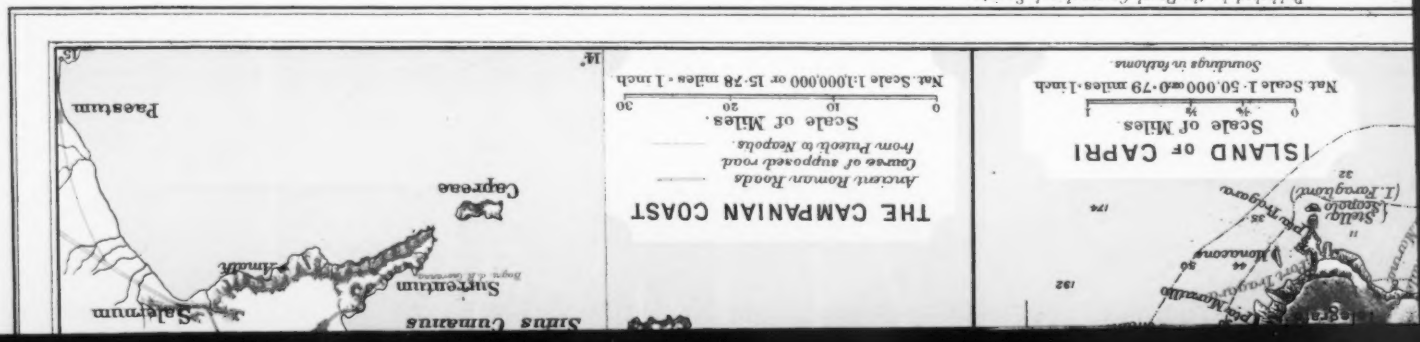

CUMA
L. Averno
M. Nuovo 1538
La Starza
L. Lucrino
VIA HERCULANEA
VIA DOMITIANA
Lago Fusaro
Baiæ
Julian Harbour
pta dell' Epitaffio
Mole
POZZUOLI
Stagnum
Torre Gaveta
Cento Camerille
Bacoli
Mare Morto
Pta Pennata
Roman Mole
Miniscola
Grotta Dragonara
Cave
C. Miseno
pta Vitareto
pta Capocchia
Anacapri
Marina Grande
CAPREAE
CAPRI
Castiglione
pta Campanello
M. Solaro
Grotta Cocuzza
pta di Pinà

10'
15'
NAPLES
Porto
Falcone
Castel dell'Ovo
Mergellina
Sannazzaro
Donn'Anna
Posilipo
Marával
C. di Posilipo
Villegio Rosebery
Lazzaretto
Roman Mole
NISIDA
C. Coroglio
Pta del Cavallo
Trentaremi B.
Scoglio di Trentaremi
Tunnel of Seiano
Armen B.
Marechiano
Pausilypon Harbour
La Gaiola
PALAEPOLIS
(Site of)
VIA ANTINIANA
Site of Lake Agnano
FORUM VULCANI
TEMPLE OF SERAPIS
ZUOLI
Bagnoli
Recent & Ancient Coast lines of the
PHLEGRAEAN FIELDS.
to illustrate the paper by
R. T. GÜNTHER, M.A.
Roman Roads.
Supposed course of roads rendered useless by subsidence.
3 Fathom line of soundings
Supposed ancient coast line.
Scale of Miles.
1 ½ 0 1
Nat. Scale 1: 75,000 or 1·183 miles = 1 inch.
Marks of Erosion visible on coast line
Caves
Antiquities
Scoglio Ricotta
Grotta del Vapore
Lo Capo
Tiberio
Grotta Tiberio
Grande
S. Michele
Pta Chiarica
White Grotta
Grotta Bianca
Scoglio Matromania
Telegrafo
Pta Marullo
Monacone
Stella
Scoglio
(I. Faraglioni)
Pta Tragara
192
174
14°
15°
41°
Caieta
VIA APPIA
Sinuessa
VIA DOMITIANA
Capua
VIA APPIA
VIAE CONSULARES
VIA POPILIA
Cumae
Baiae
Neapolis
VESUVIUS
Palaepolis
Pompeii
Procyta
Puteoli
PITHECUSA
Sinus Cumanus
Salernum
Surrentum
Amalfi
Caprese
THE CAMPANIAN COAST


M. Solaro
Grotta Cacciatori
Pta di Pino
Pta Carena
Pto del Tuoro
Grosse Grotte
Rag. Grotte
Pto Verbroso
Marina Piccola
Prod. di Malo
Grotta Azzurra
Grotta Marina
Stella
Scoglio
(I. Faraglioni
74
70
30
9
50
43
62
79
91
50
74
42
30
17
6
4
13
6
5
11
34
32
50
176

NEAPOLITAN COAST LINE.

GÜNTHER.



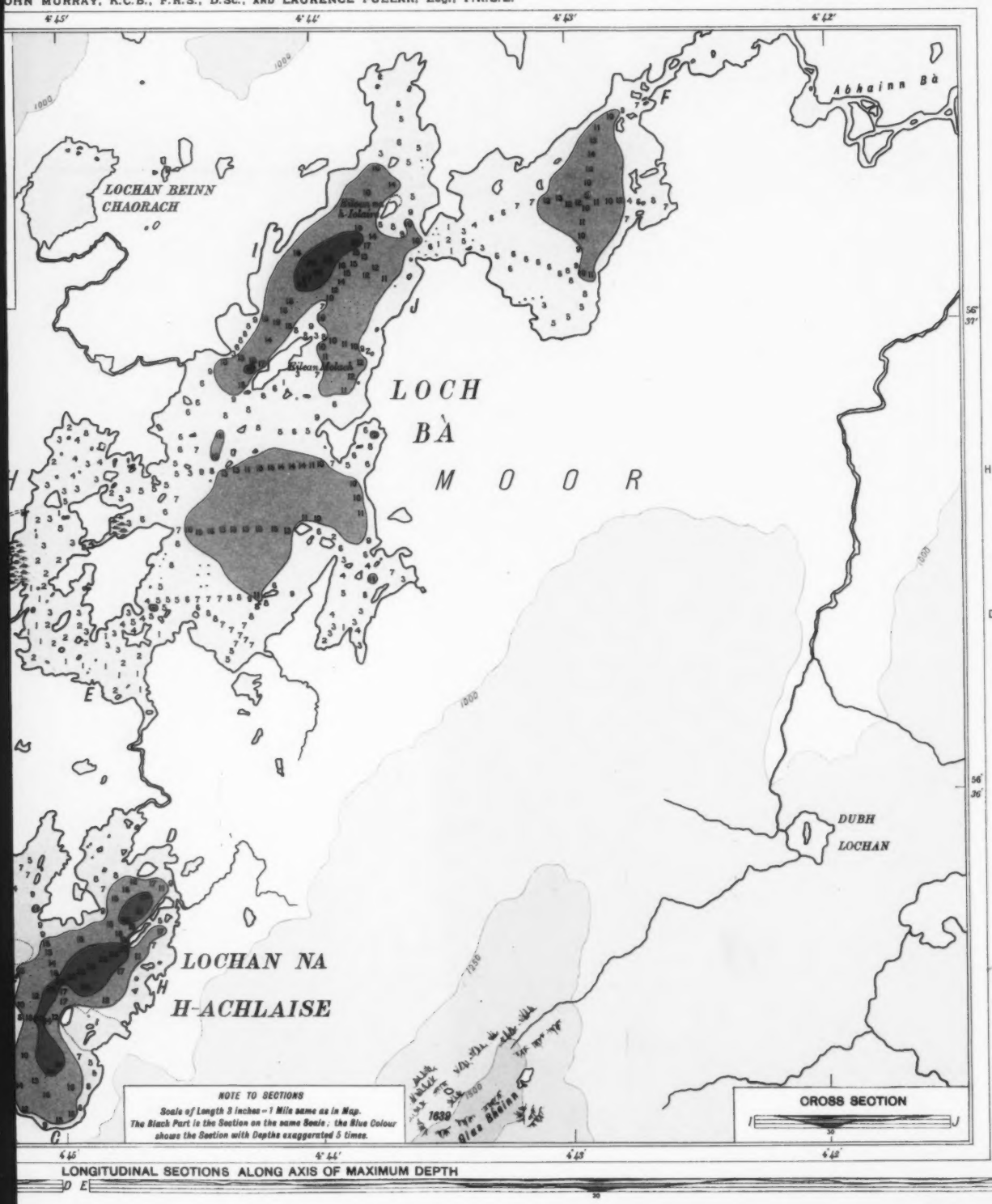
4° 47'
4° 46'
4° 45'
LOCH BÀ
LOCHAN NA H-ACHLAISE
LOCHAN NA STAINGE & LOCH BUIDHE
(TAY BASIN)
LOCH BA AND LOCHAN NA STAINGE SURVEYED IN 1902 BY
SIR JOHN MURRAY AND T. N. JOHNSTON, M.B., C.M.
LOCHAN NA H-ACHLAISE AND LOCH BUIDHE SURVEYED IN 1902 BY
JAMES PARSONS, B.Sc., R. M. CLARK, B Sc., AND D. C. M'INTOSH, M.A
Height of Surface of Water above Sea Level, Loch Ba, 957 feet
Lochan Na H-Achlaise, 962 feet, Loch Buidhe, 981 feet
The Land Contours are from the Ordnance Survey
Scale 1: 21120 3 INCHES TO 1 MILE
Mile 1
Kilometres 1·61
0·21 KILOMETRE = 1 CENTIMETRE
56° 57'
56° 56'
Beinn Chaorach
1500
1250
1000
R A N N O C H
LOCHAN NA STAINGE
LOCH BUIDHE
River Ba
Boat House
B L A C K M T
CROSS SECTION
G
H
A
B
C
D

The Edinburgh Geographical Institute

RICAL SURVEY OF THE FRESH-WATER LOCHS OF SCOTLAND

UNDER THE DIRECTION OF

JOHN MURRAY, K.C.B., F.R.S., D.Sc., AND LAURENCE PULLAR, Esq., F.R.S.E.



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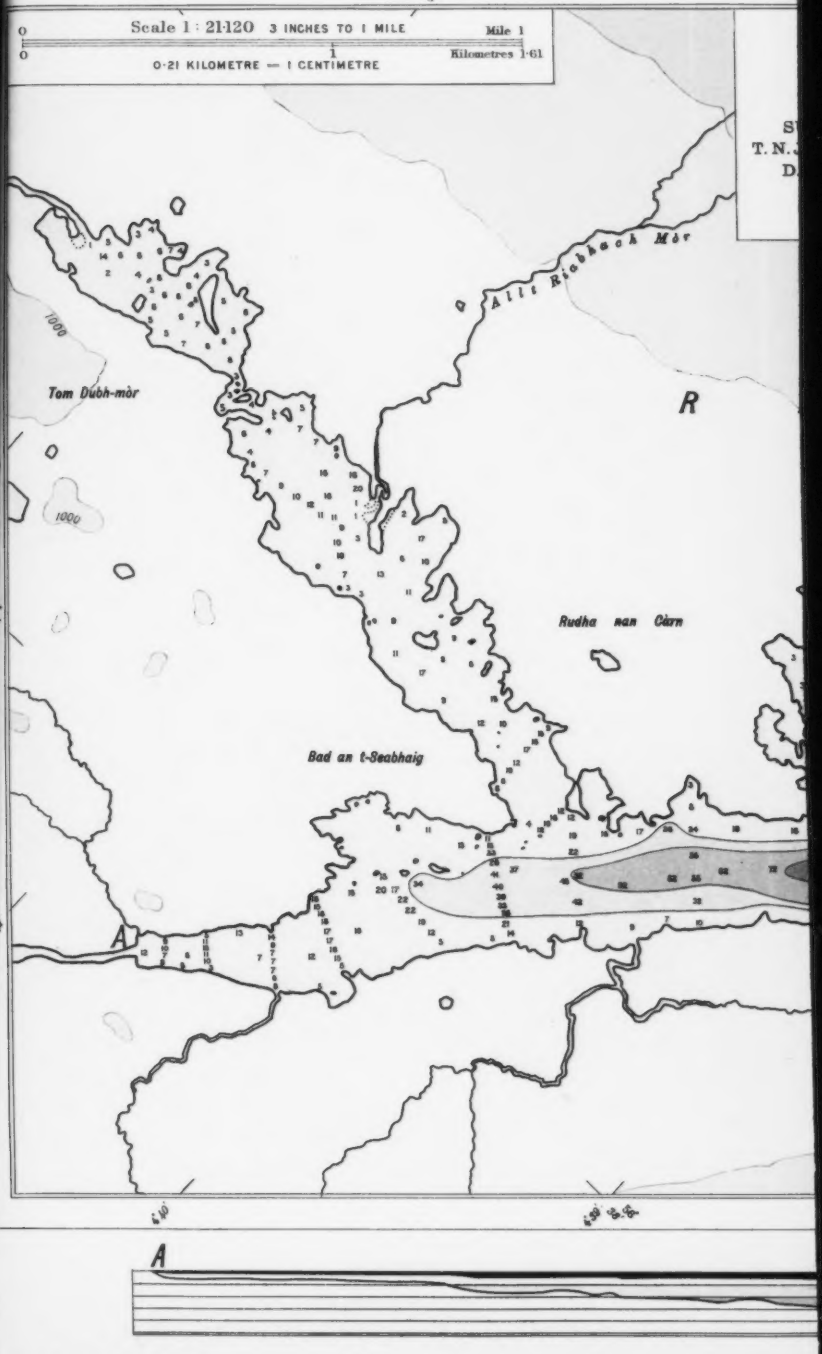
J.G. Bartholomew.

ATE II



he Edinburgh Geographical Institute

BATHYMETRICAL SURVEY OF THE FRESH-WATER LOCHS OF SCOTLAN

UNDER THE DIRECTION OF

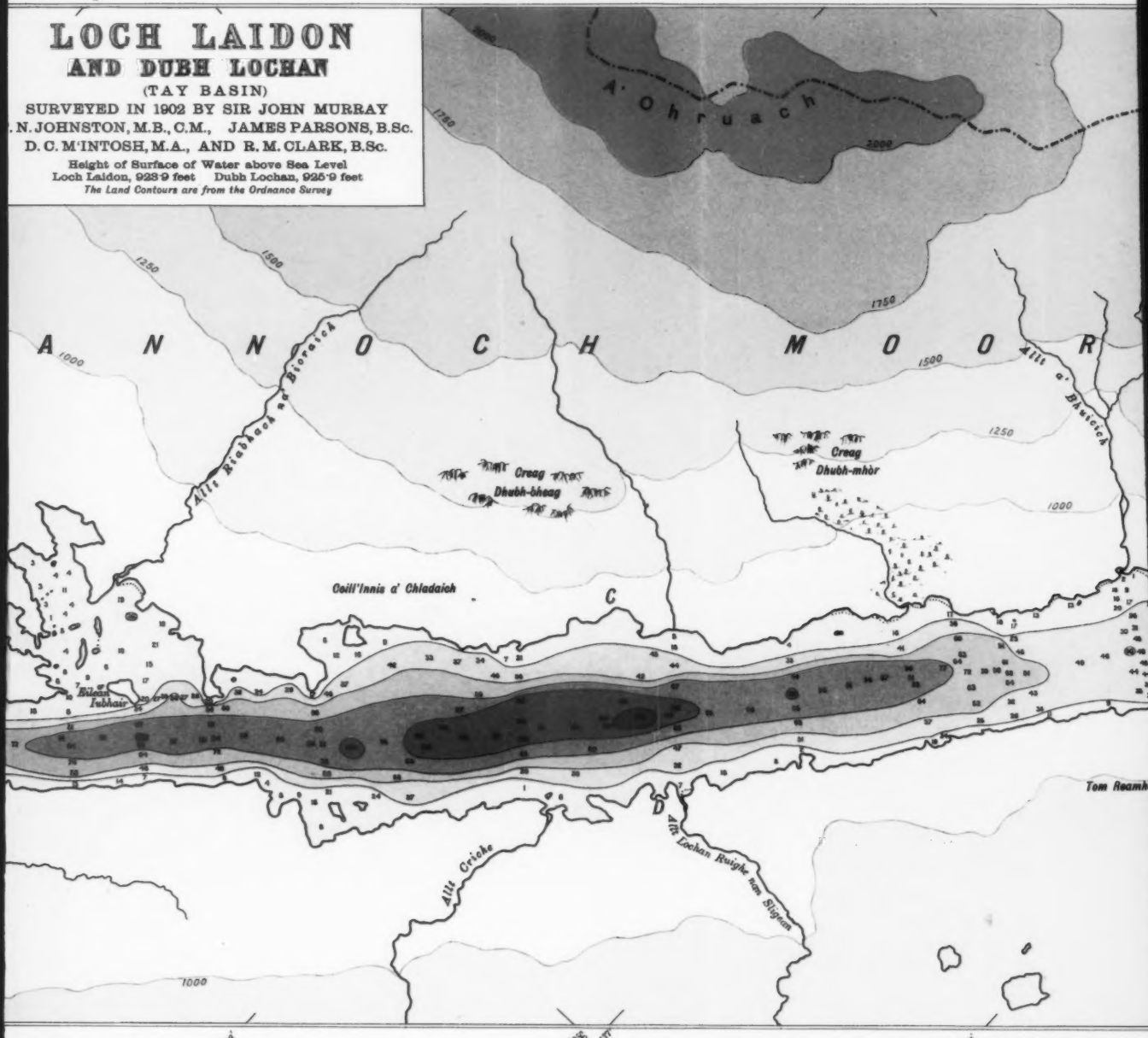
SIR JOHN MURRAY, K.C.B., F.R.S., D.Sc., AND LAURENCE PULLAR, ESQ., F.R.S.E.

LOCH LAIDON
AND DUBH LOCHAN

(TAY BASIN)

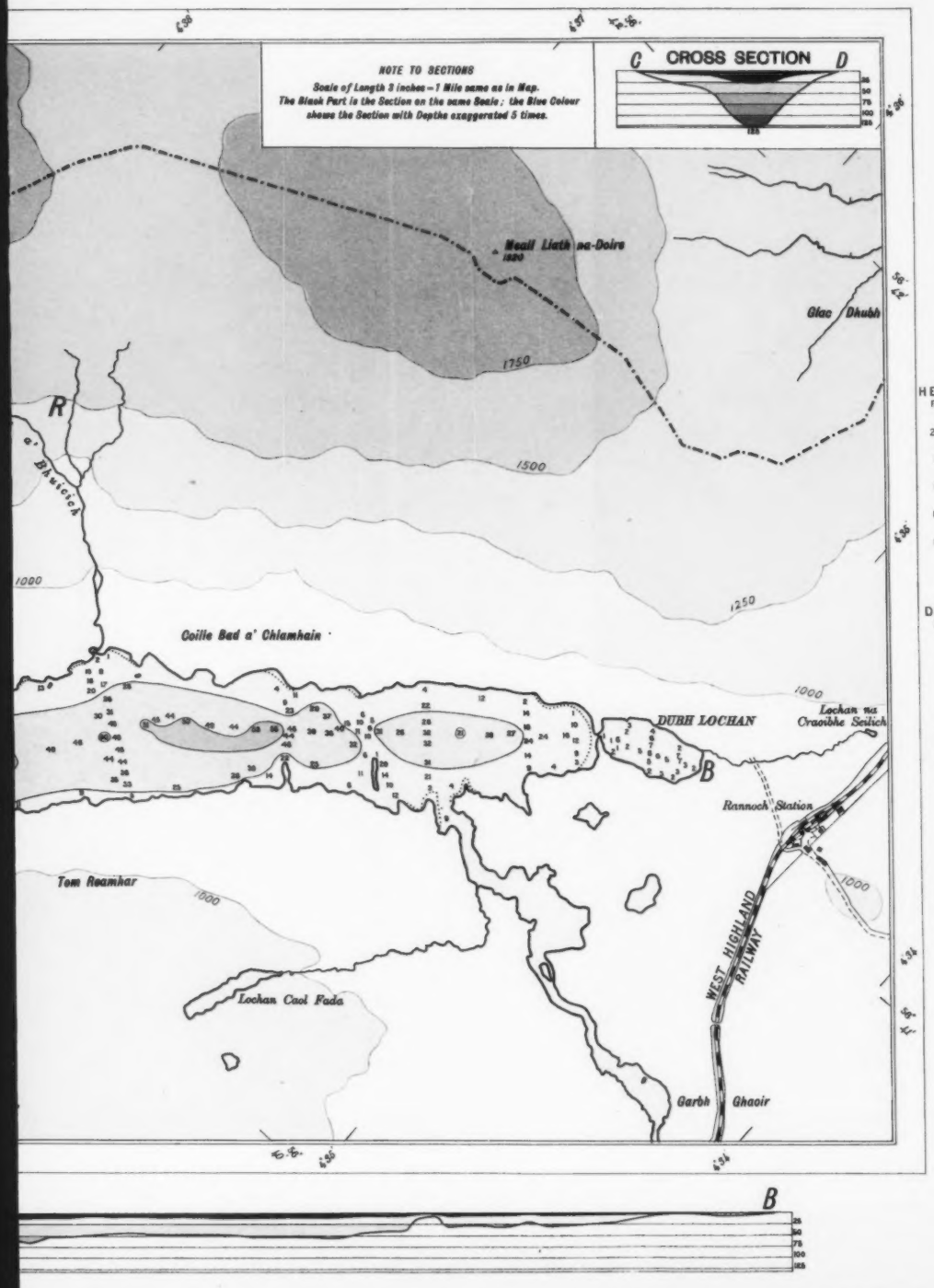
SURVEYED IN 1902 BY SIR JOHN MURRAY
. N. JOHNSTON, M.B., C.M., JAMES PARSONS, B.Sc.
D. C. M'INTOSH, M.A., AND R. M. CLARK, B.Sc.

Height of Surface of Water above Sea Level
Loch Laidon, 923·9 feet Dubh Lochan, 925·9 feet
The Land Contours are from the Ordnance Survey



LONGITUDINAL SECTION ALONG AXIS OF MAXIMUM DEPTH

Published by the Royal Geographical Society.

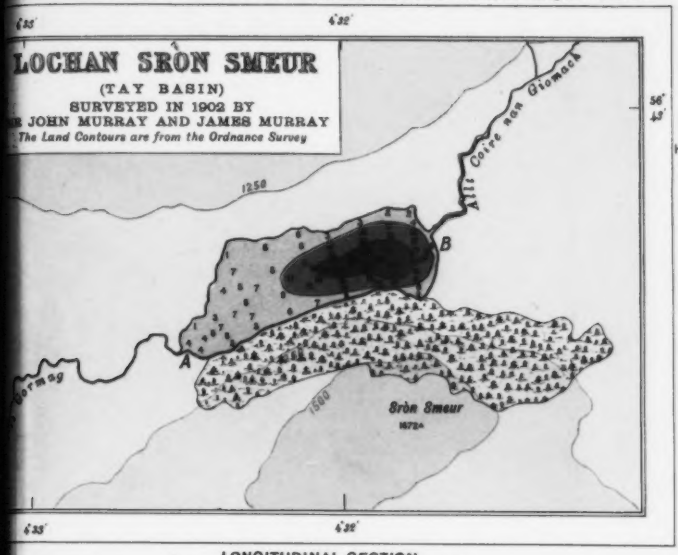


J. G. Bartholomew.

THYMETRICAL SURVEY OF THE LOCHS OF SCOTLAND

UNDER THE DIRECTION OF

JOHN MURRAY, K.C.B., F.R.S., D.Sc., AND LAURENCE PULLAR, Esq., F.R.S.E.



HEIGHTS IN FEET

FEET	METRES
1500	457·2
1250	381·1

DEPTHS IN FEET

FEET	METRES
10	3·05
20	6·1

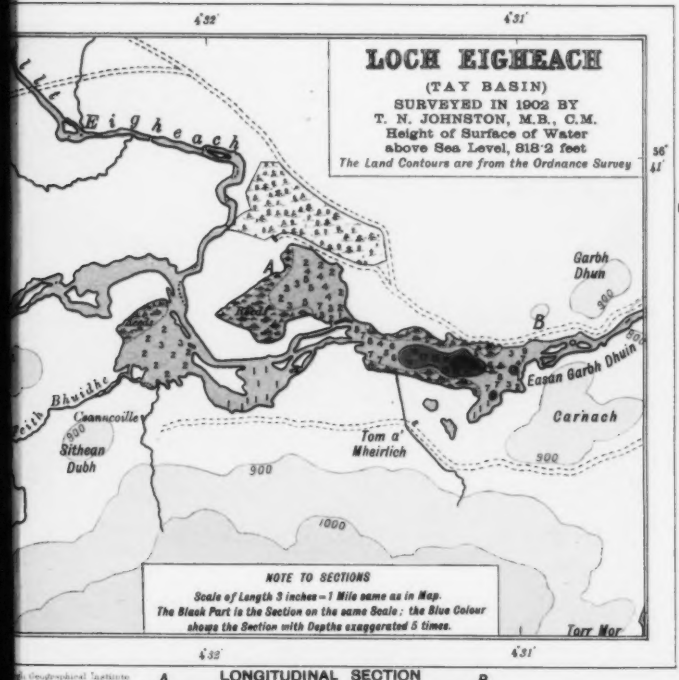
LONGITUDINAL SECTION

Scale 1 : 21120 3 INCHES TO 1 MILE

0 Mile 1

0 1 Kilometres 1·61

0·21 KILOMETRE = 1 CENTIMETRE



HEIGHTS IN FEET

FEET	METRES
1000	304·8
800	243·8

DEPTHS IN FEET

FEET	METRES
10	3·05
20	6·1

LONGITUDINAL SECTION

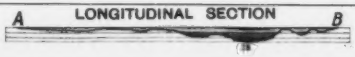


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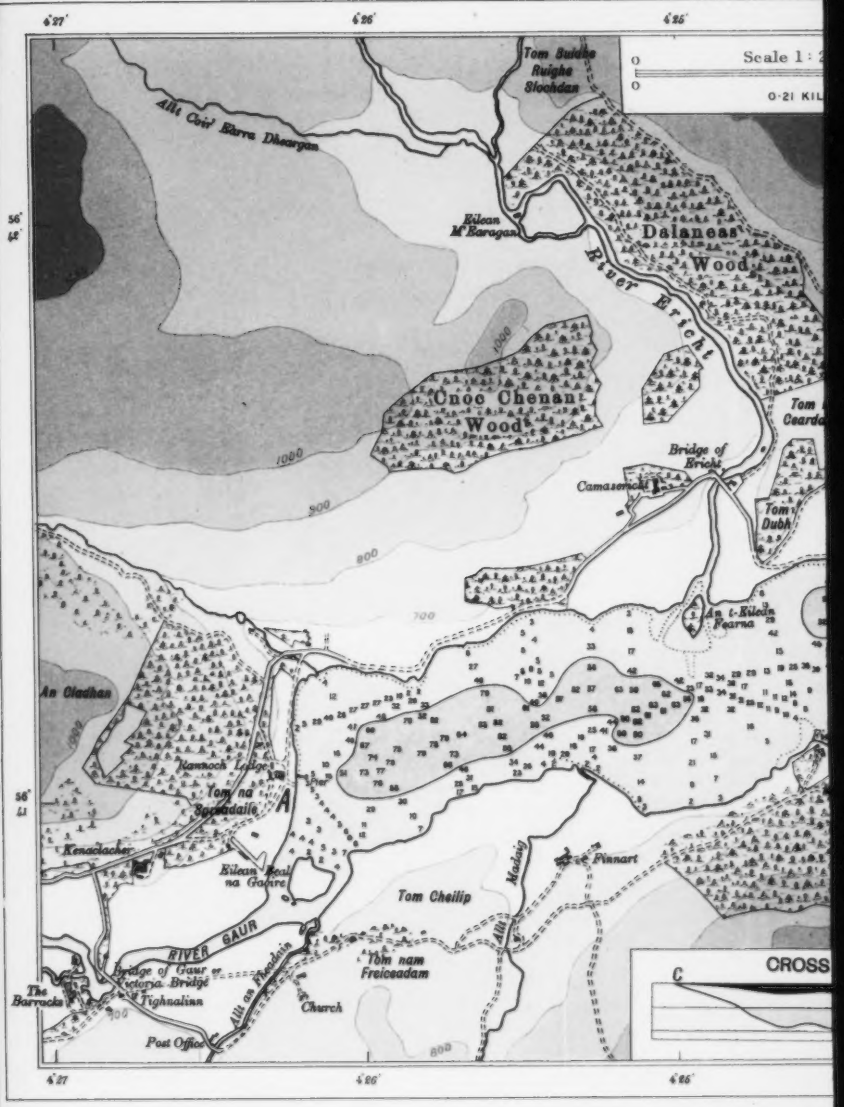
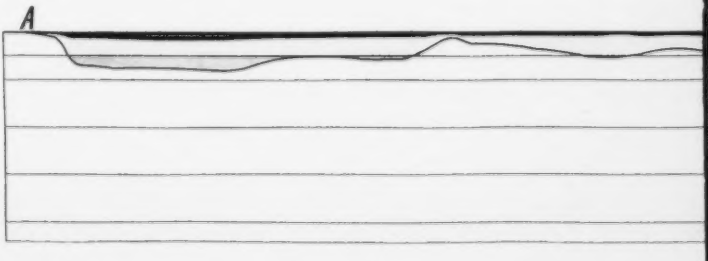
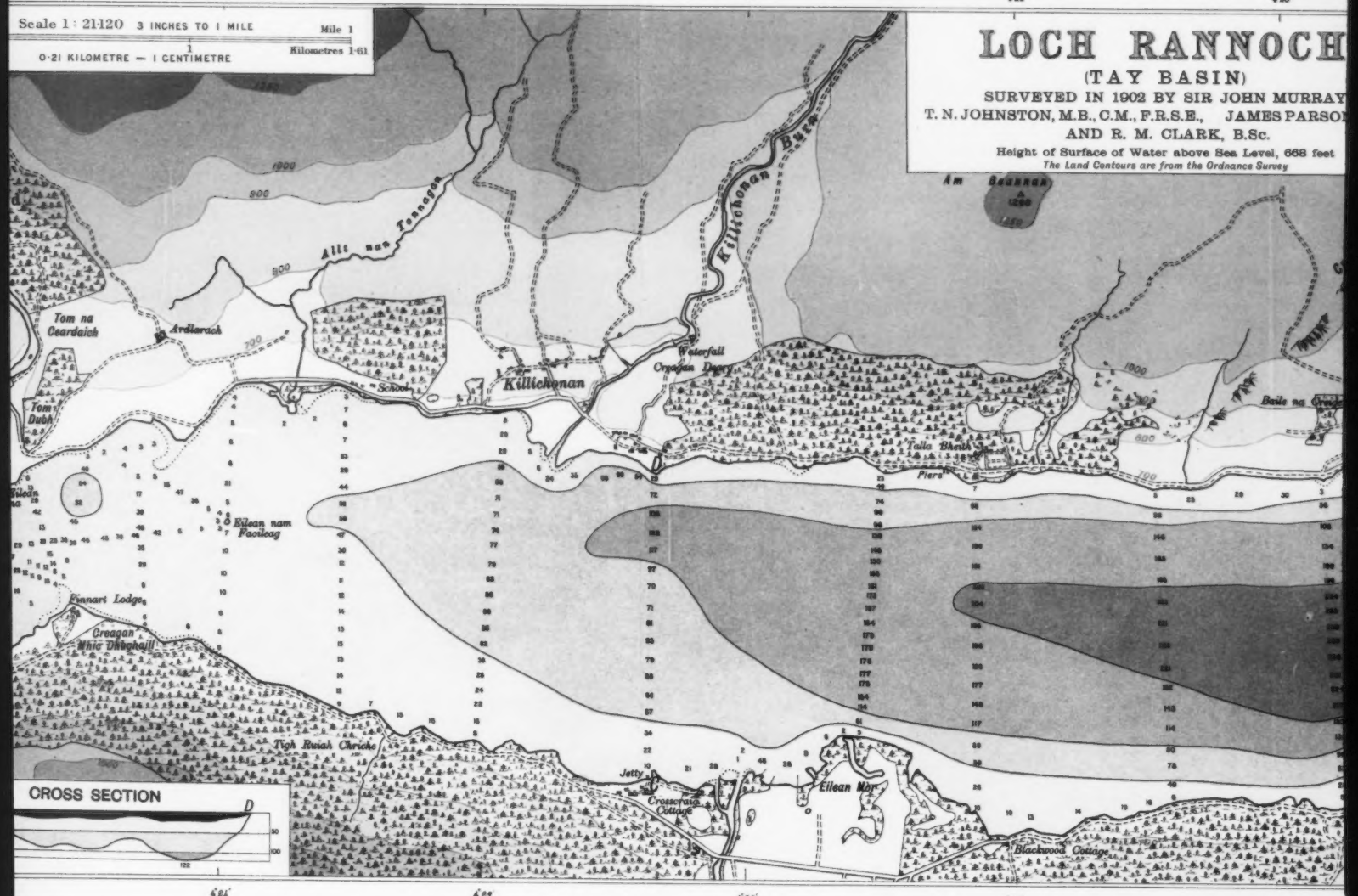
PLATE IV


6'27'
6'26'
6'25'
56° 42'
56° 41'
Tom Buidhe Ruighe Sloichdan
Allt Coir' Eirra Dhearga
Eilean M'Earagain
Dalaneas Wood
River Ericht
Cnoc Chenain Wood
1000
900
800
700
Bridge of Ericht
Camasericht
Tom Dubh
An t-Eilean Fearna
An Cladhan
Kinnoch Lodge
Tom na Boccadaile
A
Kenaclacher
Eilean Beul na Gaire
Tom Cheilip
Madaig
Pinnart
RIVER GAUR
Bridge of Gaur
Victoria Bridge
Tighnalinn
Allt an Fhaodhain
Tom nam Freiceadam
The Barracks
Church
Post Office
C
CROSS
Scale 1:
0·21 KIL


A

BATHYMETRICAL SUR

SIR JOHN MURR

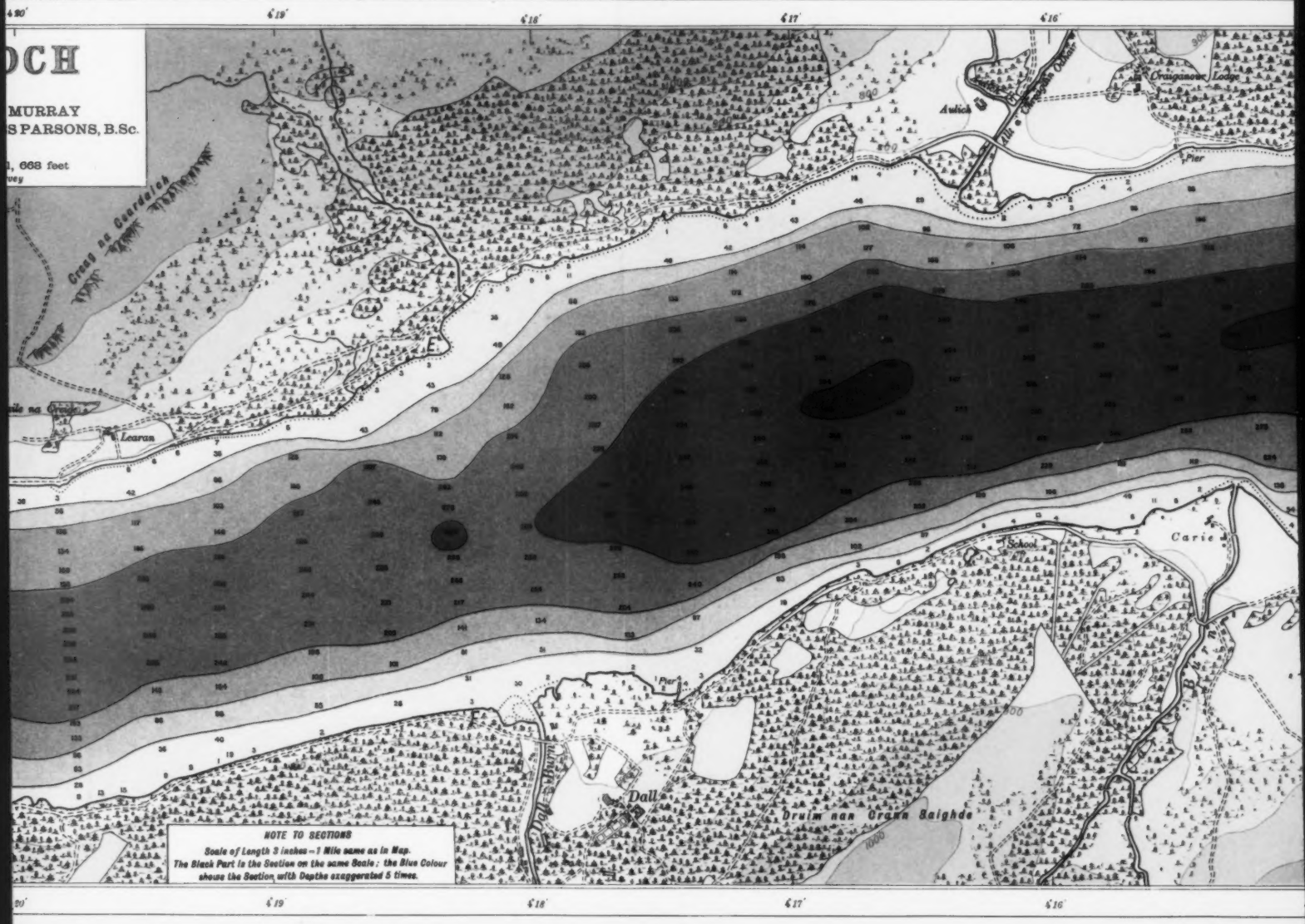


LONGITUDINA

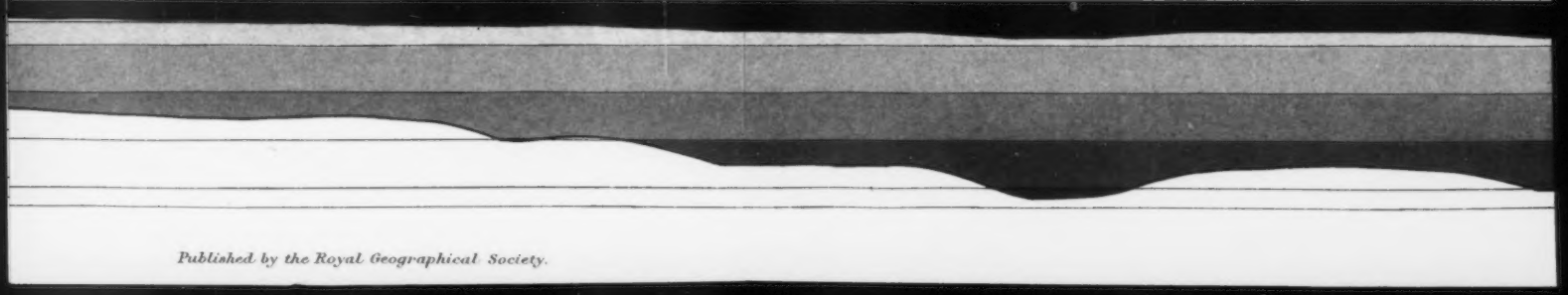
SURVEY OF THE FRESH-WATER LOCHS OF SCOTLAND

UNDER THE DIRECTION OF

N MURRAY, K.C.B., F.R.S., D.Sc., AND LAURENCE PULLAR, Esq., F.R.S.E.



UDINAL SECTION ALONG AXIS OF MAXIMUM DEPTH



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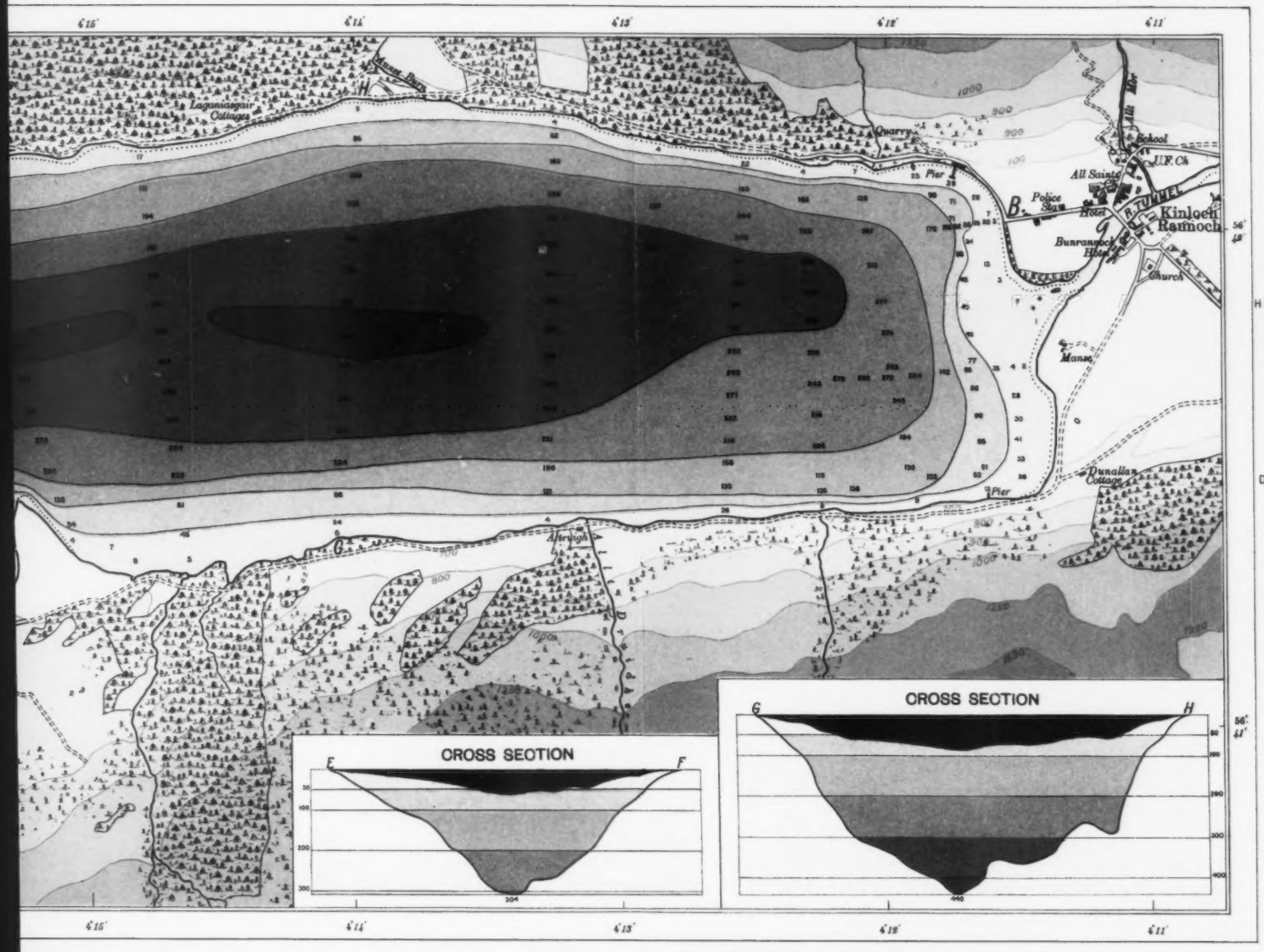
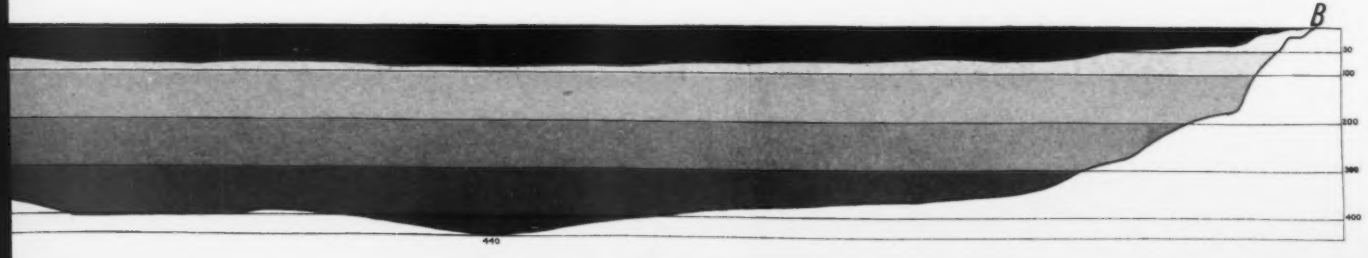
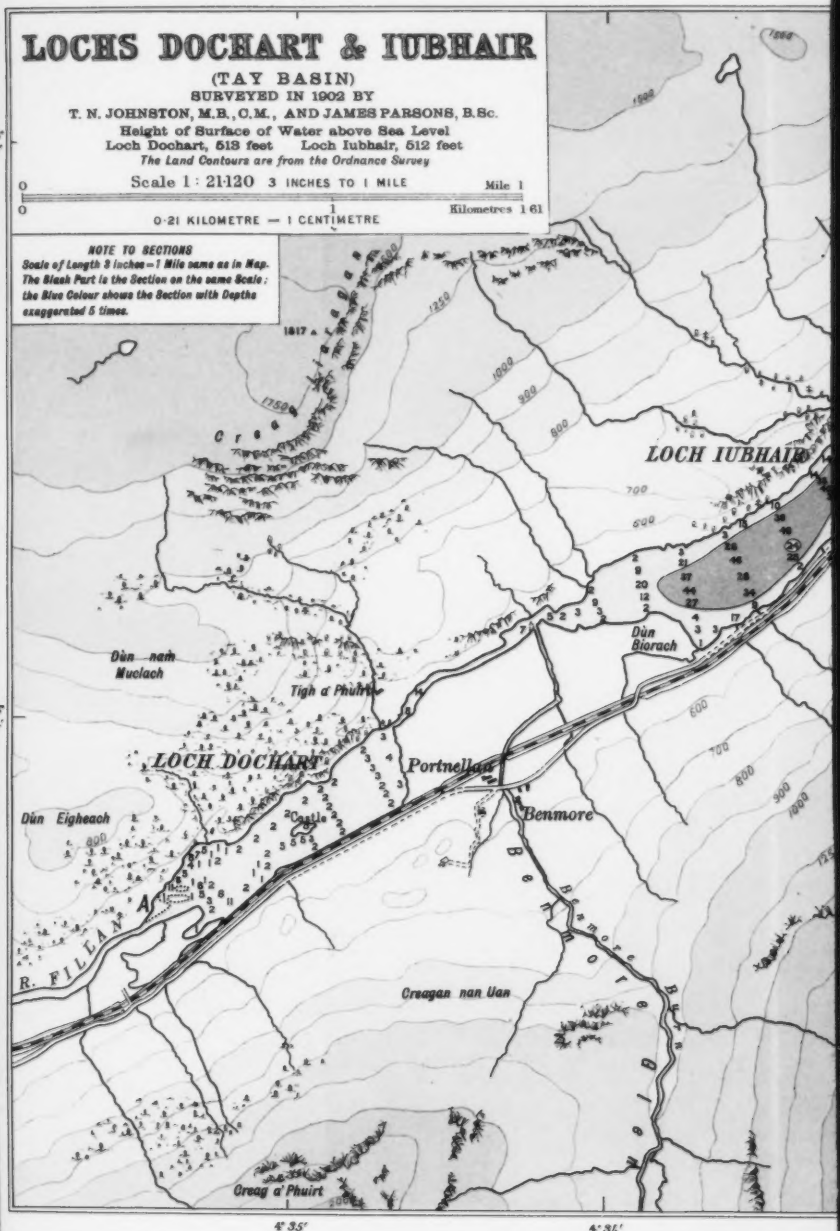




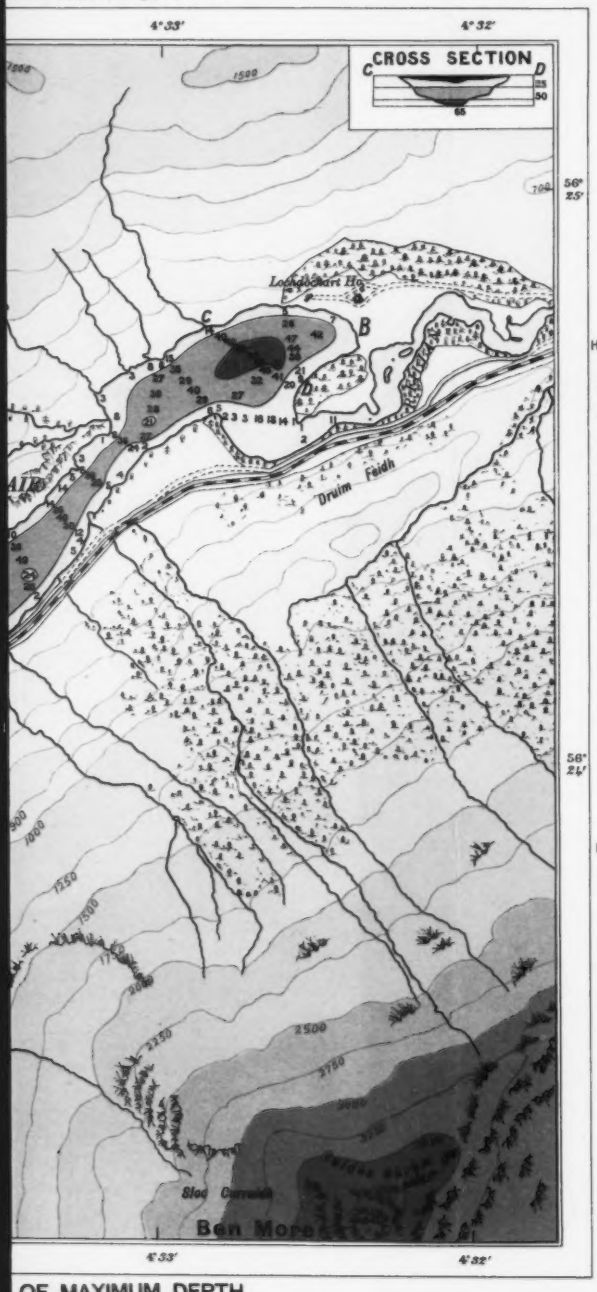
J. G. Bartholomew.


4° 35'
4° 34'
LOCHS DOCHART & IUBHAIR
(TAY BASIN)
SURVEYED IN 1902 BY
T. N. JOHNSTON, M.B., C.M., AND JAMES PARSONS, B.Sc.
Height of Surface of Water above Sea Level
Loch Dochart, 513 feet Loch Iubhair, 512 feet
The Land Contours are from the Ordnance Survey
Scale 1 : 21120 3 INCHES TO 1 MILE
Mile 1
Kilometres 1 61
0·21 KILOMETRE — 1 CENTIMETRE
NOTE TO SECTIONS
Scale of Length 3 inches = 1 Mile same as in Map.
The Black Part is the Section on the same Scale;
the Blue Colour shows the Section with Depths
exaggerated 5 times.
LOCH IUBHAIR
LOCH DOCHART
Dùn nam Muclach
Tigh a' Phuirt
Dùn Biorach
Portnellan
Benmore
Dùn Eigheach
Castle
R. FILLAN
Creagan nan Uan
Creag a' Phuirt
56° 25'
56° 24'

LONGITUDINAL SECTION ALONG AXIS OF M

ATER LOCHS OF SCOTLAND

NCE PULLAR, Esq., F.R.S.E.



OF MAXIMUM DEPTH

l. Society.

J.G. Bartholomew.

BATHYMETRICAL SURVEY OF THE FRESH-WATER L

UNDER THE DIRECTION OF

SIR JOHN MURRAY, K.C.B., F.R.S., D.Sc., AND LAURENCE PULL

LOCH LYON

(TAY BASIN)

SURVEYED IN 1902 BY SIR JOHN MURRAY
T. N. JOHNSTON, M.B., C.M., AND
JAMES PARSONS, B.Sc.

Height of Surface of Water
above Sea Level, 1052 feet

The Land Contours are from the Ordnance Survey

4°38′ 4°37′ 4°36′

56° 32′ 56° 31′

Eilean Riabhach
Gleann Meran
Allt Meran
Creag Bhuidhe
Meallan Odhar
Bad nan Ceare
Garbh Leachtir
Benvannoch
Eilrig
Allt Fionn a' Ghlinne
Abhainn Ghlas
Ford
Luban
Famochoarn
An Stuchd

CROSS SECTION C D
25
50
75
100

LONGITUDINAL SECTION ALONG AXIS OF MA

A

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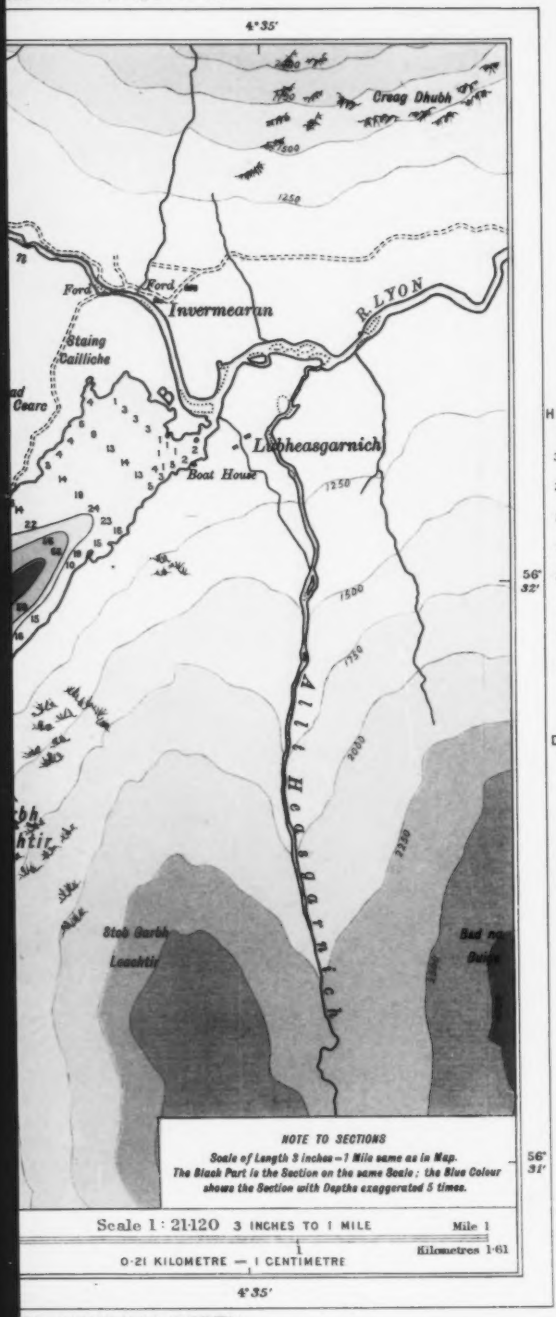
...TER LOCHS OF SCOTLAND

...NCE PULLAR, Esq., F.R.S.E.



HEIGHTS IN FEET

FEET	METRES
3000	914·4
2750	838·2
2500	762
2250	685·8
2000	609·6
1750	533·4
1500	457·2
1250	381·1

DEPTHS IN FEET

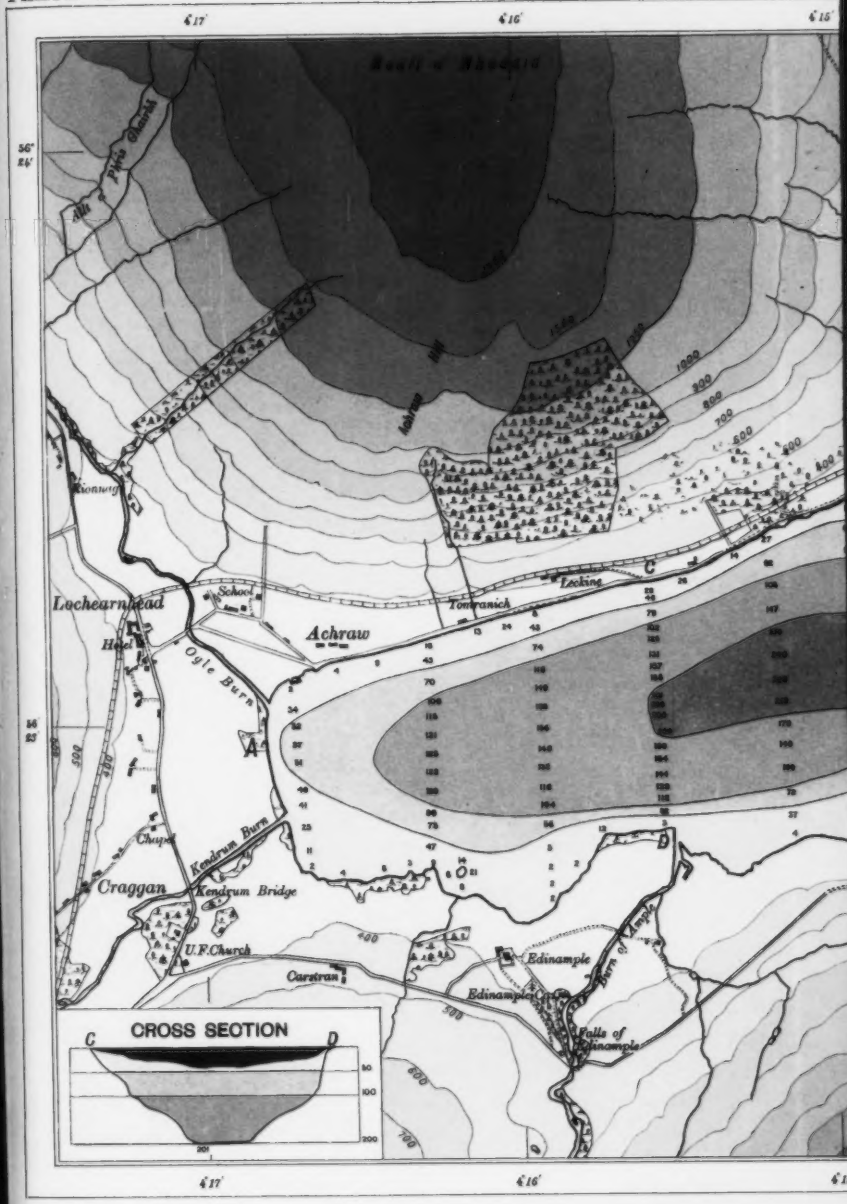
FEET	METRES
25	7·6
50	15·2
75	22·9
100	30·5

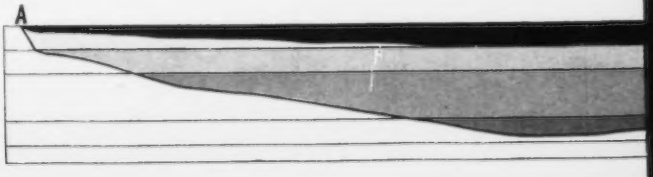
...OF MAXIMUM DEPTH

...al Society.

J. G. Bartholomew.

PLATE VII

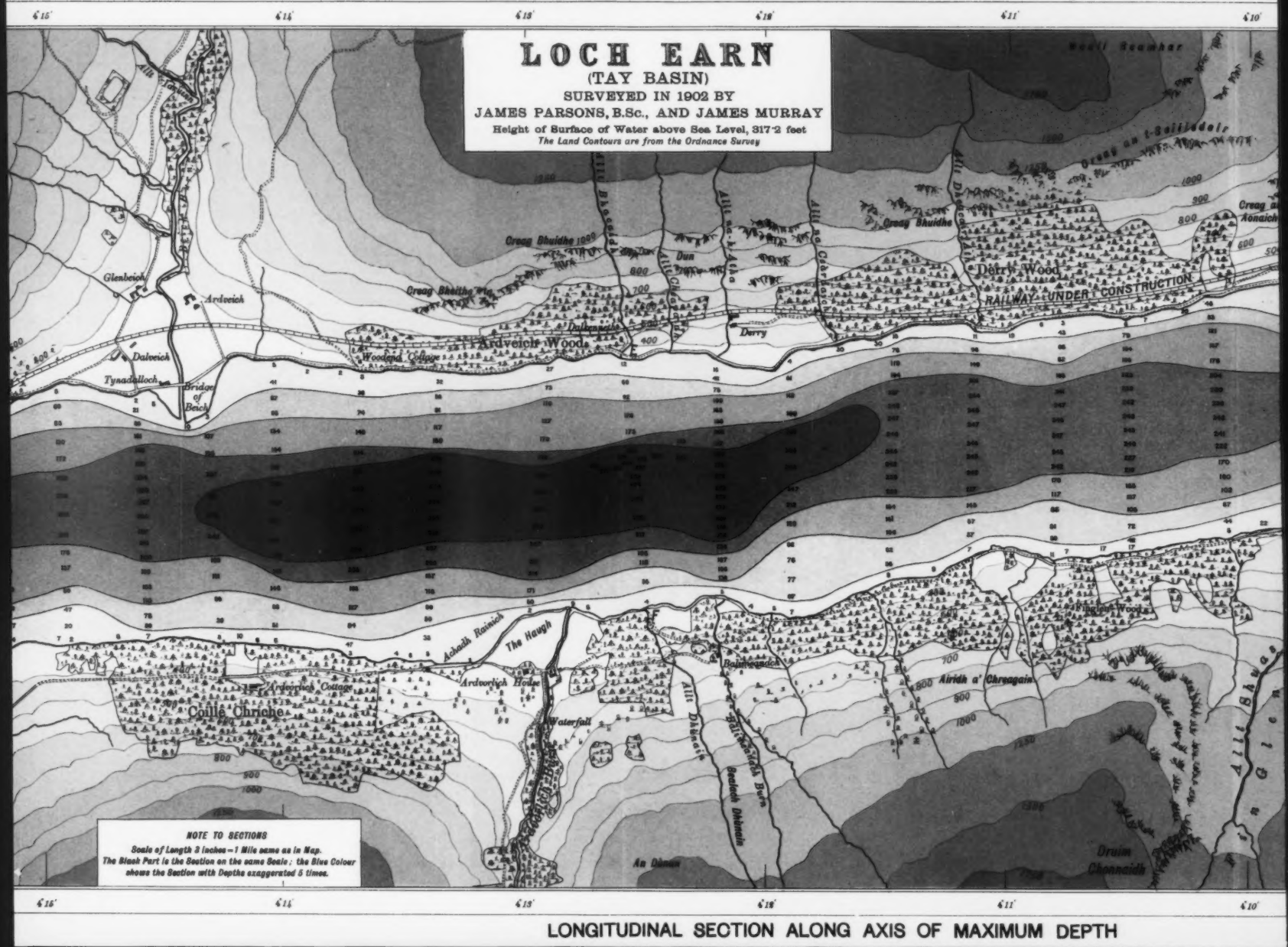

4°17'
4°16'
4°15'
56° 24'
56° 23'
Beinn a' Bhuiridh
Ben Lui
Ben a' Phuis Chaorich
Kirkton
Lochearnhead
Hotel
School
Achraw
Tombranich
Lecking
Ogle Burn
Chapel
Kendrum Burn
Craggan
Kendrum Bridge
U.F.Church
Caretran
Edinample
Burn of Edinample
Edinample Castle
Falls of Edinample
A
B
C
D
CROSS SECTION
C
D
50
100
200
201
1000
900
800
700
600
500
400
300


A

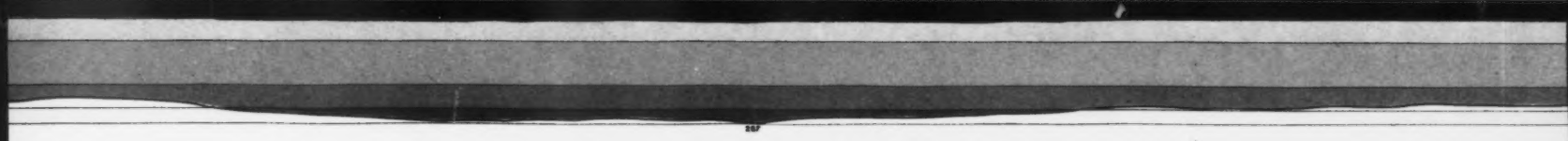
BATHYMETRICAL SURVEY OF THE FRESH-WATER LOCHS OF SCOTL

UNDER THE DIRECTION OF

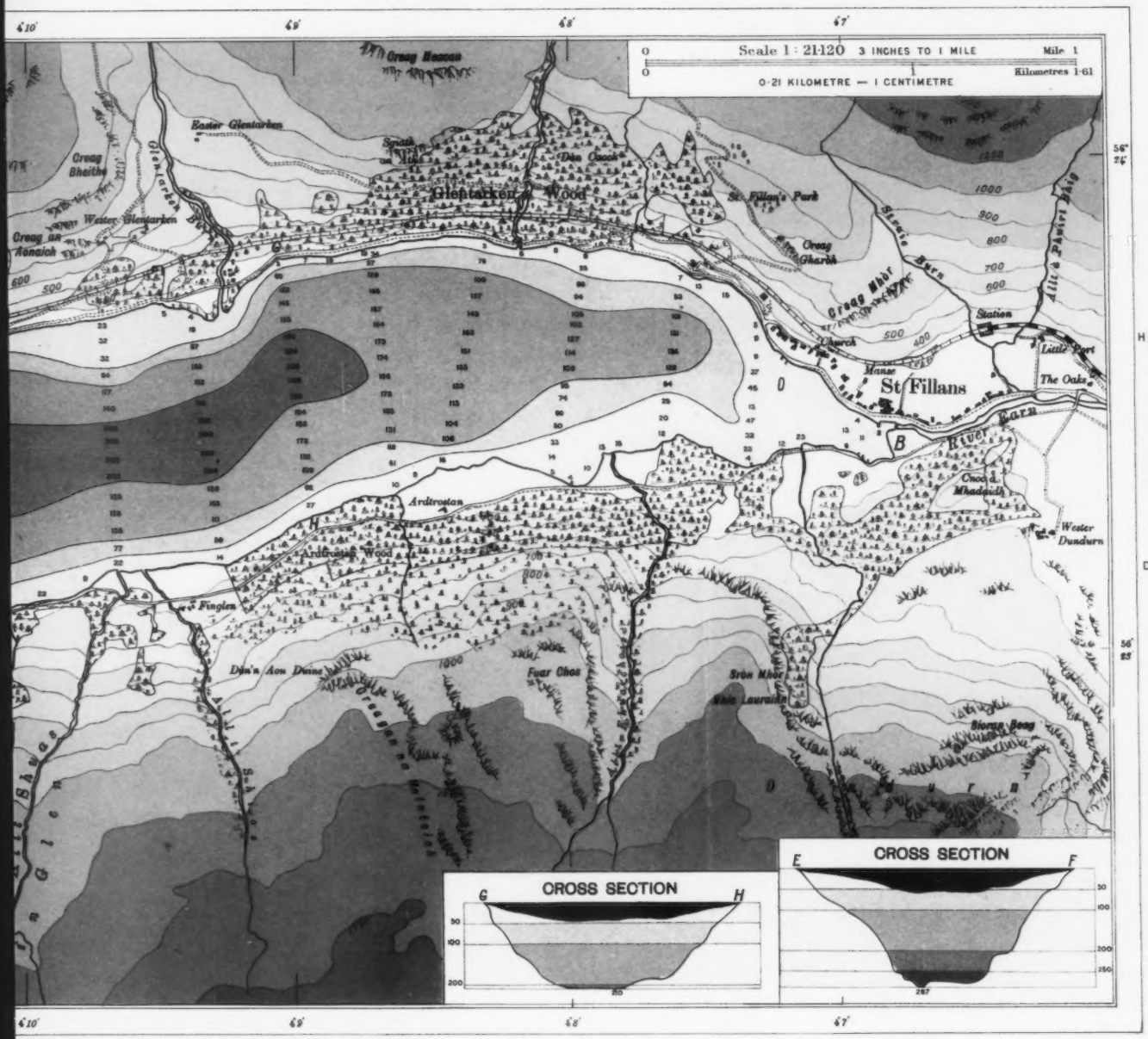
SIR JOHN MURRAY, K.C.B., F.R.S., D.Sc., AND LAURENCE PULLAR, ESQ., F.R.S.E.

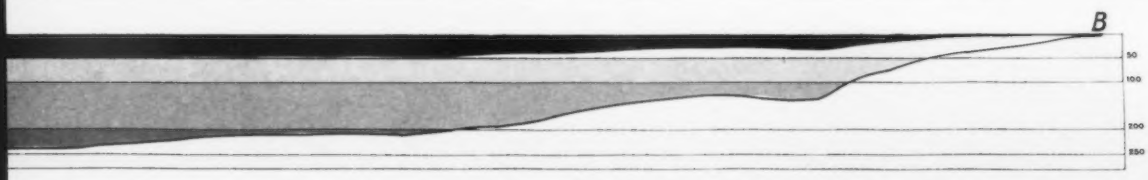


LONGITUDINAL SECTION ALONG AXIS OF MAXIMUM DEPTH



Published by the Royal Geographical Society.





J. G. Bartholomew.